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Manual of Mineralogy

By J. Nicol.

Edinburgh, 1849.

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PREFACE.

MINERALOGY has recently made rapid progress in every ment. The forms of crystals are now better understood, an dependence on each other, and on the axes of the system more accurately determined, and expressed in simple and clearer language, than a few years ago might have been considered possible. Many additions have also been made to our knowledge of the physical properties of minerals, especially their relations to the subtler agents, light, electricity, magnetism, enlarging its bounds and heightening the interest of the study. The number of exact chemical analyses has likewise greatly increased, confirming or correcting the views formerly entertained of the constitution of many important species. These analyses, too, are interpreted in a more intelligible manner, and their results exhibited in definite formulæ. Hence the value of the science much extended, and its true place in the Natural History of the Earth fully vindicated. No geologist, without a knowledge of its principles, can now pretend to explain the nature or formation of the igneous and crystalline rocks,—rocks covering more than a fifth part of the surface of Britain, and probably an equal proportion of the whole dry land on the globe. It is clearly seen that the chemical characters, the geognostic position, the modes of association of simple minerals, must be thoroughly studied, before we can hope to solve many of the highest problems in geology. The theory of metamorphism, whether from igneous action, or

the more gradual but not less certain or efficacious agency of chemical and electric forces;—the origin of mineral veins, with the manner in which they have been filled, and the various ores, or other substances, collected and arranged in them;—the sources whence plants, and through them animals, derive that unfailing supply of mineral substances needed for their growth and healthful development, so that fertility and life are diffused over the ·rth;—these and many other interesting questions must ever ·n obscure without a due acquaintance with this department History of Nature.

preparing this Manual, the Author has endeavoured to bear e facts in mind, and to give such a view of the present state of the science as might be required for the general purposes of the student, or serve as an introduction to the further investigation of some particular department. It has been his wish to treat of each portion with that fulness which its importance might require, nd especially to establish the true crystallographic and chemical haracter of the species. The former is illustrated by numerous gures; the latter by a more complete series of the best and ost recent analyses than is to be found, he believes, in any other nglish work on Mineralogy. In this attempt he has been reatly aided by the labours of several of his predecessors. hough special references to these have frequently been made, e deems it but justice again to acknowledge his obligations to Naumann, Mohs, G. Rose, Haidinger, in the crystallographic and introductory part of his work; to Rammelsberg in the chemical characters and analyses of minerals; to Weiss and Hartmann for the classification adopted; and to the writings of these authors, of Jameson, Phillips, Allan, and especially the very elaborate treatise of Hausmann, for much information on the general history, the mode of occurrence, and the geognostic and geographical position of the various species. The titles of these and some other of the more important books consulted are given in the subjoined list,

which may be useful to the student who wishes to pursue the subject further. The Author regrets that the limits of this list do not admit of particular reference to numerous Memoirs scattered through the Transactions of learned Societies, and Scientific Periodicals, from which much valuable information has been derived.

In a work of such extent, containing so many numbers, and in which almost every word expresses a definite fact, errors can scarcely be avoided. The Author has endeavoured to diminish their number by careful and repeated revision, and trusts that those overlooked may be found comparatively few, and not such as to interfere with the utility of the volume. He would gladly hope that, with all its defects, the work may in some measure aid in promoting the study of this branch of science, and in extending the knowledge of those wonders of Creative Wisdom with which the Mineral Kingdom, like every other portion of Nature, so richly abounds.

LONDON,
20*th March* 1849.

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ERRATA.

Page 28, line 17, *for* m *read* n.
Page 42, line 1, *for* R, *read* ∞R.
Page 347, line 17, *for* much *read* no.
Page 373, line 26, dele ' Nickeline, *Beudant*;' and in head-line of same page, *for* NICKELINE, *read* NICKEL-OCHRE.

TABULAR VIEW

OF THE

ARRANGEMENT OF MINERALS,

AND OF THEIR MORE

IMPORTANT CHARACTERS,

INTENDED TO FACILITATE THE DISCOVERY OF THE NAMES OF SPECIES.

Note.—The following table being designed to serve as a guide to the full descriptions in the work, and not to supersede reference to these, only the more prominent points have been selected. More would have been unnecessary repetition, greatly increasing the bulk of the table, and consequently lessening its utility. The number prefixed to each name is that under which the species is described. In the second column, the crystal-system, or the massive or amorphous character of the species, is given ; Rhdr means rhombohedric ; rh. or rhm, rhombic ; the other abbreviations require no explanation. The third column contains the hardness, the fourth the specific gravity. The fifth has reference to the action of acids, and the sixth to the effects of heat applied by the blowpipe.

The following abbreviations are employed in these columns:—

ACIDS.		ACIDS.	
Sol.	= soluble	pot.	= solution of potash
Ins.	= insoluble	wtr.	= water
Af.	= affected	con.	= concentrated
Ef.	= effervesces	w.	= warm
Gel.	= gelatinizes	!	= very, or, great
n.	= nitric acid	Imp.	= imperfectly
h.	= hydrochloric	Pul.	= pulverized
s.	= sulphuric	Ig.	= when ignited
ncl.	= nitro-chloric	Sil.	= leaves silica

BLOWPIPE.		BLOWPIPE.	
Fus.	= fusible	Wtns.	= becomes white
Inf.	= infusible	Eas.	= easily
Int.	= intumesces	Dif.	= difficultly
Der.	= decrepitates	Edg.	= on the edges only
Exf.	= exfoliates	En.	= forms an enamel
Vol.	= volatilizes	Gls.	= a glass
Sub.	= sublimes	Hep.	= an hepatic mass
Fms.	= gives out fumes	Crst.	= crystallized
Red.	= is reduced	Mag.	= magnetic
Phos.	= phosphoresces	Ars.	= arsenious fumes
Cl.fl.	= colours the flame	Sul.	= sulphurous fumes
Bkns.	= blackens	Ant.	= antimonious

I. ORDER—OXIDIZED STONES.

Name.	Crystallization.	Hardness.	Specific Gravity.	Acids.	Blowpipe.
I. Fam.—Quartz.					
1 Quartz	Rhdr.	7·	2·65	Ins.	Inf.
2 Opal	Amor.	5·5—6·6	2—2·2	Ins. ; sol. pot.	Decrep. inf.
II. Felspar.					
3 Orthoclase.....	Mncl.	6	2·53—2·6	Ins.	Fus. dif.
4 Ryacolite	Mncl.	6	2·57, 2·6	Sol. h. imp.	Fus.
5 Albite	Tricl.	6—6·5	2·6—2·7	Insol.	Fus. dif.
6 Andesin.....	Tricl.	6	2·73	Insol.	Fus.
7 Saccharite.....	Mass.	5—6	2·66—2·7	Sol. imp.	Fus. edg.
8 Labradorite ..	Tricl.	6	2·68—2·74	Sol. h.	Fus.
9 Couzeranite ...	Mncl.	6	2·69	Insol.	Fus. en.
10 Anorthite	Tricl.	6	2·7—2·76	Sol. h.	Fus. gls.
11 Oligoclase	Tricl.	6	2·64—2·66	Insol.	Fus. gls.
12 Petalite	Cl. ?	6·5	2·4—2·5	Insol.	Fus. gls.
13 Spodumene ...	rh. ?	6·5—7	3·07—3·2	Insol.	Fus. int. gls.
14 Kastor	Mncl.	6—6·5	2·38—2·4	Insol. h.	Fus. dif. fl.yel.
15 Pollux	?	6—6·5	2·87—2·9	Sol. w. h.	Fus. edg.
16 Amorph.felspar	Comp.	5—7	2·2—2·4	...	Fus. gls. en.
III. Scapolite.					
17 Scapolite	Tet.	5—5·5	2·6—2·8	Sol. h.	Fus. ef. gls.
18 Nuttalite	Tet.	5·5	2·7	Sol.	Fus. ef. gls.
19 Barsowite	Mass.	5·5—6	2·7—2·76	Gel. h.	Fus. dif. gls.
20 Ottrelite.....	Mass.	5—	4·4	Sol. w.	Fus. dif. edg.
21 Palagonite.....	Amor.	5 ?	2·43	Sol. h.	Fus. mag.
22 Dipyr	Tet.	...	2·6	Af. ac.	Fus. gls.
23 Nepheline.....	Hex.	5·5—6	2·58—2·64	gel. h.	Fus. dif. gls.
24 Davyne	Hex.	5—5·5	2·42—2·46	Sol. ef. h.	Fus. gls.
25 Gehlenite	Tet.	5·5—6	2·98—3·1	Gel. h.	Fus. dif.
26 Humboldtilite..	Tet.	5—5·5	2·90—2·95	Gel. h.	Fus. eas. gls.
27 Prehnite.....	Rhm.	6—7	2·8—3	Sol. h.(ig. gel.)	Fus. eas. en.
28 Zeuxite, &c. ...	...	...	...	.....	.....
29 Nephrite	Comp.	6—6·5	2·9—3	.....	Fus. int. en.
IV. Haloid Stones.					
30 Lazulite.....	Rhm.	5—6	3—3·1	Imp. sol.	Infus. int.
31 Calaite	Amor.	6	2·6—2·8	Sol.	Infus. cl.fl.
32 Wavellite	Rh.	3·5—4	2·3—2·5	Sol.	Int. cl.fl.
33 Wagnerite.....	Mncl.	5—5·5	2·9—3·0	Sol. n. s.	Fus. dif.
34 Amblygonite ..	Rh.	6	3—3·1	Sol. s. h.	Fus. eas.
35 Alunite	Rhdr.	3·5—4	2·6—2·8	Sol. s. ; ins. h.	Infus.
36 Aluminite	?	1	1·7	Sol. h.	Infus. ; fm.
37 Pissophane....	?	2	1·92—1·98	Sol. h.	Blkns.
38 Latrobite	Trcl.	5—6	2·7—2·8	.....	Int. fus. edg.

Name.	Crystallization.	Hardness.	Specific Gravity.	Acids.	Blowpipe.
V. Leucite.					
39 Leucite	Tess.	5·5—6	2·4—2·5	Sol. h.	Infus.
40 Porcelain spar	Rh.	5·5	2·67—2·68	Sol. h.	Fus. eas.
41 Sodalite	Tess.	5·5	2·28—2·29	Gel.	Fus. eas.
42 Hauyne	Tess.	5—5·5	2·4—2·5	Sol. h.	Decr. fus.
43 Nosean	Tess.	5·5	2·25—2·27	Sol. h.	Fus.
44 Ittnerite	Tess.	5.5	2·37—2·4	Gel. h.	Fus. ef.
45 Lapis Lazuli	Tess.	5·5	2·38—2·42	Gel. h.	Fus. eas.
46 Eudialite	Rhdr.	5—5·5	2·84—2·95	Gel. h.	Fus. eas.
VI. Zeolites.					
47 Analcime	Tess.	5·5	2·1—2·25	Gel. h.	Fus.
48 Natrolite	Rh.	5—5·5	2·17—2·26	Gel. h.	Fus.
49 Scolezite	Mncl.	5—5·5	2·2—2·3	Gel. h.	Fus. twists.
50 Damourite	Mass.	1·5	2·7—2·8	Sol. s. insol. h.	Fus. dif.
51 Thomsonite	Rh.	5—5·5	2·3—2·4	Gel. h.	Fus. dif. int.
52 Stilbite	Rh.	3·5—4	2·1—2·2	Sol. h.	Fus. dif. int. !
53 Aedelforsite	Mass.	6	2·6	Gel.	Fus. int.
54 Heulandite	Mncl.	3·5—4	2·1—2·2	Sol. dep. sil.	Exf. ; int. ; fus.
55 Brewsterite	Mncl.	5—5·5	2·12—2·2	Sol. dep. sil.	Fus. int.
56 Epistilbite	Rh.	3·5—4	2—2·2	Sol. h.	Fus. en.
57 Apophyllite	Tet.	4·5—5	2·3—2·4	Sol. exf. h.	Fus. en. ; exf.
58 Okenite	Rh.	5	2·28—2·36	Sol. gel. h.	Fus. en. frths.
59 Pectolite	Mncl. ?	5	2·69—2·74	Sol. h. ; ig. gel.	Fus. eas.
60 Chabasite	Rhdr.	4—4·5	2—2·2	Sol. or gel. h.	Fus. en.
61 Faujasite	Tet.	...	1·9—2	Sol. h.	Fus. int.
62 Harmotome	Rh.	4·5	2·3—2·4	Sol. h. dif.	Fus. dif.
63 Phillipsite	Rh.	4·5	2·15—2·19	Gel. h.	Fus. eas.
64 Zeagonite, *Naum*	Tet.	6—6·5	2·18	Gel. h.	Infus.
— Zeagonite, *Haus.*	?	4·5	...	Gel. h.	Fus. eas.
65 Laumonite	Mncl.	3—3·5	2·2—2·3	Gel. h.	Fus. eas.
66 Leonhardite	Mncl.	3—3·5	2·25	Sol.	Fus. eas. ; exf.
67 Glottalite	Tess.	3—4	2·18	.....	Fus. int. en.
68 Edingtonite	Tet.	4—4·5	2·7—2·75	Gel. h.	Fus. dif.
VII. Mica.					
69 Potash-Mica	Mncl.	2—3	2·8—3·1	Insol.	Fus.
70 Lithia-Mica	Mncl. ?	2—3	2·8—3·1	Sol. impr.	Fus. eas.
71 Magnesia-Mica	Hex.	2·5—3	2·85—2·9	Sol. s.	Fus. dif.
72 Lepidomelane	Hex.	3	3·0	Sol. h. n.	Fus. blk. mag.
73 Chloritoid	Mass.	5·5—6	3·55	Insol.	Inf. mag.
74 Chlorite	Hex.	1—1·5	2·78—2·96	Sol. s.	Fus. dif. edg.
75 Ripidolite	Rhdr.	2—3	2·61—2·77	Sol. s.	Exf. ; fus. edg.
76 Talk	Rh. mncl.	1	2·68—2·75	Insol.	Inf. exf.
77 Schillerspar	Mncl.	3·5—4	2·6—2·8	Sol. s. ; imp. h.	Fus. mag.
78 Antigorite	?	2·5	2·62	Sol. h. dif.	Fus. dif. en.
79 Hydropite	Mass.	3—4	2·65	.....	Infus.
80 Serpentine	?	3—3·5	2·5—2·6	Sol. s. h.	Fus. dif.
81 Picrosmine	Rh.	2·5—3	2·5—2·7	.....	Inf. (H. = 5.)
82 Villarsite	Rh.	3	2·9—3	Sol. dif.	Infus.

Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
83 Spadaite	Amorph.	2·5		Sol. eas. h.	Fus.
84 Gymnite	Mass.		2·216	Sol. con. h. sil.	Fus.
85 Chonikrite ...	Mass.	2·5—3	2·91	Sol. h.	Fus. boils.
86 Pyrosklerite	Rh. ?	3	2·7—2·8	Sol. h.	Fus. dif.
87 Kammererite	Hex.	1·5—2	2·76	.. ..	Inf. exf.
88 Pyrosmalite...	Hex.	4—4·5	3—3·2	Sol. n.	Fus.
89 Cronstedtite...	Rhdr.	2·5	3·3—3·5	Gel. h.	Int. fus. edg.
90 Stilpnomelan	Mass.	3—4	3—3·4	Sol. imp.	Fus. dif.
91 Brucite.....	Hex.	2	2·3—2·4	Sol. eas.	Infus.
92 Hydromagnesite	Amorph.	1·5—2	?	Sol. eff.	Infus.
93 Nemalite	Fibrous	2	2·4	Sol. slow. ef.	Inf.
94 Seybertite ...	Hex. ?	4·5—6	3—3·16	Sol. con. ac.	Inf.
95 Margarite.....	Monocl.	3·5—4·5	3·03	Sol.	Int. fus. dif.
96 Pyrophyllite	Rh. ?	1	2·7—2·8	Sol. imp. s.	Inf. exf.
97 Anauxite	Mass.	2—3	2·26	.....	Fus. edg.
98 Pholerite	Mass.	0·5—1	2·3—2·6	Ins. h.	Infus.
99 Rosellan	Mass.	2·5	2·72	.....	Fus. dif.
VIII. Hornblende.					
100 Hornblende...	Monocl.	5—6	2·9—3·4	Ins. sol. imp.	Fus. int.
101 Augite	Monocl.	5—6	3·2—3·5	Sol. imp.	Fus.
102 Hypersthene	Monocl.	6	3·3—3·4	Insol.	Fus. eas.
103 Bronzite	Monocl.	4·5—5	3·2—3·5	Insol.	Fus. dif.
104 Diallage	Mass.	4	3·2—3·3	Insol.	Fus. eas.
105 Rhodonite ...	Monocl.?	5—5·5	3·5—3·6	Insol.	Fus.
106 Tephroite.....	Tet.	5·5	4·0—4·2	Gel. h.	Fus. eas.
107 Troostite	Rhdr.	5·5	4·0—4·1	Sol. n.	Fus. edg.
108 Wollastonite	Monocl.	5	2·7—2·9	Gel. h.	Fus. dif.
110 Achmite	Monocl.	6—6·5	3·5—3·6	Sol. imp.	Fus. eas.
111 Sordawalite ...	Mass.	4—4·5	2·5—2·6	Sol. imp.	Fus.
112 Krokydolite...	Mass.	4	3·2—3·3	Insol.	Fus. eas.
113 Pyrallolite ...	Tricl.	3·5—4	2·5—2·6	Insol. (?)	Fus. dif. edg.
114 Pyrargillite ...	Rh. ?	3·5	2·5	Sol. h.	Infus.
115 Karpholite ...	Fibrous	5—5·5	2·9—3	Sol. imp. !!	Fus. int.
116 Babingtonite	Tricl.	5—5·5	3·4—3·5	Sol. w. h.	Fus. eas. ef.
117 Isopyre	Amorph.	5·5—6	2·9—3	Sol. impf.	Fus. mag.
118 Polylite	Mass.	6—6·5	3·23	.....	Infus.
119 Tachylite ...	Amorph.	6·5	2·52	Sol. h.	Fus. eas.
IX. Clays.					
120 Kaolin	Mass.	1	2·2	Sol.w.s.;insol.h	Infus.
121 Clay.....	Comp.		1·8—2·7	. ....	Fus.
122 Rock soap ...	Comp.	1—2		.....	
123 Plinthite	Comp.	2—3	2·34	.....	Inf. bkns.
124 Green-earth ...	Mass.	1—2	2·8	Insol.	Fus.
125 Yellow-earth	Comp.	1—2	2·2	Sol. imp. h.	Inf.
126 Halloysite ...	Amorph.	1·5—2·5	1·9—2·1	Sol. con. s.	Infus.
127 Fuller's Earth	Amorph.	1—1·5	1·8—2	Sol. con. s.	
128 Allophane ...	Mass.	3	1·8—2	Gel.	Inf. int.
129 Schrötterite...	Amorph.	3—3·5	1·9—2	Gel. h.	Inf. whtns.

	Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
130	Challilite.....	Comp.	4·5	2·25	... ..	Inf. whtns.
131	Bole.....	Comp.	1—2	2·2—2·5	Sol.	Fus.
132	Teratolite.....	Comp.	2·5—3	2·5	.....	Infus.
133	Kollyrite	Comp.	1—2	2—3	Gel. imp.	Infus.
134	Lithomarge ..	Comp.	2·5—3	2·4—2·6	.. ...	.....
135	Miloschin.....	Comp.	2	2·13	Sol. imp. h.	Infus.
136	Kerolite	Mass.	2—3	2·3—2·4	.....	Infus.
137	Agalmatolite	Mass.	2—3	2·8—2·9	Sol. w. s.	Fus. edg.
138	Soapstone ...	Mass.	1·5	2·26	Sol. s.	Fus.
139	Pipestone.. ...	Comp.	1·5	2·6	.....	Infus.
140	Meerschaum	Comp.	2—2·5	0·8—1	Sol. h.	Fus. edg.
141	Pimelite	Mass.	2·5	2·23—2·3	.....	Fus. edg.
142	Dermatin.....	Comp.	2·5	2·13	.....	Bkns.
143	Retinalite.....	Mass.	3·5	2·5	.....	Inf. wtns.
	X. Garnet.					
144	Garnet.....	Tess.	6·5—7·5	3·5—4·3	Sol. impf. h.	Fus. eas.
145	Pyrope	Tess.	7·5	3·7—3·8	Insol.	Fus. dif.
146	Helvine	Tess.	6—6·5	3·1—3·3	Sol. h.	Fus. intum.
147	Idocrase	Tet.	6·5	3·3—3·5	Sol. imp. h.	Fus. eas.intum.
148	Epidote	Monocl.	6—7	3·2—3·5	Ign. sol.	Fus.
149	Axinite	Tricl.	6·5—7	3—3·3	Ign. sol.	Fus. eas.intum.
150	Cyanite	Monocl.	5—7	3·5—3·7	Insol.	Infus.
151	Sillimanite ...	Tricl. ?	7—7·5	3·2—3·3	Insol.	Infus.
152	Bamlite	Monocl. ?	6—7	2·98	... ..	Infus.
153	Andalusite ...	Rh.	7—7·5	3·1—3·3	Insol.	Infus.
154	Staurolite.....	Rh.	7—7·5	3·5—3·8	Ins. h.; imp. s.	Infus.
155	Diaspore	Rh.	6	3·3—3·4	Insol.	Decrep. infus.
156	Hydrargillite	Hex.	2·5—3	2·3—2·4	Sol. w. ac.	Exf. infus.
157	Periclase	Tess.	6	3·75	Sol. pul.	Infus.
158	Glaucophane	Rh. ?	5·5	3·10	Sol. imp.	Fus. eas.
	XI. Gems.					
159	Zircon	Tet.	7·5	4—4·7	Insol.	Infus.
160	Malacon	Tet.	6	3·9	Sol. pul. s.	Infus.
161	Spinel	Tess.	8	3·4—3·8	Insol.	Infus.
162	Automalite ...	Tess.	8	4·1—4·3	Insol.	Infus.
163	Corundum ...	Rhdr.	9	3·9—4	Insol.	Infus.
164	Chrysoberyl...	Rhm.	8·5	3·68—3·8	Insol.	Infus.
165	Topaz	Rhm.	8	3·4—3·6	Insol.	Infus.
166	Pycnite	Mass.	7·5	3·4—3·6	Insol.	Infus.
167	Leucophane. .	Tricl. ?	3·5—4	2·97	.....	Fus.
168	Euclase	Monocl.	7·5	3—3·1	Insol.	Fus. intum.
169	Emerald	Hex.	7·5—8	2·6—2·8	Insol.	Fus. dif. edg.
170	Phenakite ...	Rhdr.	7·5—8	2·9—3	Insol.	Infus.
171	Iolite	Rhm.	7—7·5	2·5—2·7	Sol. imp.	Fus. slow
172	Tourmaline...	Rhdr.	6·5—7·5	3—3·3	Sol. imp. s.	Fus.; or int.
173	Chrysolite ...	Rh.	6·5—7	3·3—3·5	Gel. s.	Infus.
174	Chondrodite...	Monocl.	6·5	3·1—3·25	Sol.	Fus. dif. edg.

Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
XII. Metallic Stones.					
175 Liëvrite	Rh.	5·5—6	3·9—4·2	Gel. h.	Fus. eas.
176 Hisingerite ...	Mass.	3·5—4	2·6—3	Sol. ; sil.	Fus. dif.
177 Anthosiderite	Mass.	6·5	3	Sol. h.	Fus. dif. ma
178 Nontronite ...	Mass.	1	2·08	Gel. w. acids.	Dcr. mag.; i
179 Pinguite	Mass.	1	2·3—2·4	Sol. h. ; sil.	Fus. edg.
180 Chloropal.....	Mass.	2·5—3	2·1—2·2	Sol. h. imp.	Infus.
181 Chlorophaeite	Mass.	Soft.	2·02	.....	Fus.
182 Thorite.....	Mass.		4·6—4·8	Gel. h.	Infus.
183 Eulytine	Tess.	4·5—5	5·9—6	Gel. h.	Fus. eas.
184 Gadolinite ...	Mncl.	6·5	4—4·4	Gel. h.	Incan. int.
185 Allanite	Rhm.	6	3·2—3·7	Gel. h.	Fus. frths.
186 Tschewkinite	Mass.	5—5·5	4·53	Gel. w. h.	Int. fus.
187 Cerite	Hex.	5·5	4·9—5	Sol. h. gel. s.	Inf. yel.
188 Pyrochlore ...	Tess.	5	3·8—4·3	Sol. con. s.	Fus. dif.
189 Oerstedtite ...	Tet.	5·5	3·63	.....	Infus.
190 Keilhauite ...	Mass.	6—7	3·69	Sol. h. pul.	Fus. eas.
191 Wöhlerite ...	?	5—6	3·41	Sol. w. con. h.	Fus.
192 Polymignite...	Rhm.	6·5	4·806	Sol. con. h.	Inf.
193 Polykrase.....	Rhm.	5—6	5—5·15	Sol. s.; h. imp.	Inf. dcr.
194 Perowskite ...	Tess.	5·5	4	Af. imp.	Infus.
195 Aeschynite ...	Rhm.	5—5·5	4·9—5·1	Sol. con. s. imp.	Inf. int.
196 Mengite	Rhm.	5—5·5	5·48	Sol. w. con. s.	Inf. mag.
197 Monazite	Mncl.	5—5·5	5—5·25	Sol. h.	Inf.
198 Samarskite ...	Rhm.	5·5	5·625	Sol. h.	Fus.
II. Order.—Saline Stones.					
I. Fam. Calc-Spar.					
199 Calc-spar	Rhdr.	3	2·6—2·8	Sol. h. n. ef.	Inf.
200 Dolomite	Rhdr.	3·5—4·5	2·8—2·95	Sol. h. dif.	Inf.
201 Breunnerite ...	Rhdr.	4—4·5	2·9—3·1	Sol. w. ac.	Inf. mag.
202 Magnesite ...	Comp.	3—5	2·8—3	Sol. w. ac.	Infus.
203 Mesitine-spar	Rhdr.	3·5—4	3·3—3·4	Sol. w. ac.	Inf.
204 Arragonite ...	Rhm.	3·5—4	2·9—3	Sol. h. n. ef.	Inf. dcrp.
II. Fluor-Spar.					
205 Fluor-Spar ..	Tess.	4	3·1—3·2	Sol. s. h. n.	Decrp. fus.
206 Yttrocerite ...	Mass.	4—5	3·4—3·5	Sol. h.	Infus.
207 Fluocerite ...	Hex.	4—5	4·7	.....	Inf. Fl.
208 Fluocerine ...	Mass.	4·5	.....	.....	Inf. Fl.
209 Cryolite	Rhm.?	2·5—3	2·9—3	Sol. s. h.	Fus. eas.
210 Chiolite	Rhm.	4	2·72	Sol. s.	Fus. eas.
211 Hopeite	Rhm.	2·5—3	2·76	Sol. ac.	Fus. eas.
212 Apatite	Hex.	5	3·16—3·22	Sol. n. h.	Fus. dif.
213 Herderite.....	Rhm.	5	2·9—3	Sol. w. h.	Fus. dif.
214 Childrenite ...	Rhm.	4·5—5	.....	.....	... ..
215 Xenotime ...	Tet.	4·5	4·39	.....	Inf.
216 Boracite	Tess.	7	2·9—3	Sol. h.	Fus. dif.

	Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
217	Hydroboracite	Mass.	2	1·9—2	Sol. h. n.	Fus. eas.
218	Datolite	Mncl.	5—5·5	2·9—3	Gel. h.	Fus. eas.
	III. Heavy Spar.					
219	Barytes	Rhm.	3—3·5	4·3—4·7	Ins.	Dcrp. fus. dif.
220	Dreelite	Rhdr.	3—4	3·2—3·4	Sol. h. imp. ef.	Fus. eas.
221	Witherite ...	Rhm.	3—3·5	4·2—4·3	Sol. h. n. ef.	Fus. eas.
222	Alstonite	Rhm.	4—4·5	3·6—3·8	Sol. h. ef.	Infus.
223	Baryto-calcite	Mncl.	4	3·6—3·7	Sol. h. ef.	Inf.
224	Celestine	Rhm.	3—3·5	3·9—4	Slight af.	Dcr. fus. eas.
225	Strontianite ...	Rhm.	3·5	3·6—3·8	Sol. ef.	Fus. dif. ; int.
	IV. Gypsum.					
226	Gypsum	Mncl.	1·5—2	2·2—2·4	Insol.	Exfol. fus. en.
227	Anhydrite ...	Rhm.	3—3·5	2·8—3	Insol.	Fus. dif. en.
228	Polyhalite ...	Rhm.	3·5	2·7—2·8	Sol. wtr.	Fus.
229	Glauberite ...	Mncl.	2·5—3	2·7—2·85	Dcm. wtr.	Decr. fus.
230	Pharmacolite	Mncl.	2—2·5	2·6—2·8	Sol. eas.	Fus. en ; ars. fm.
231	Haidingerite	Rhm.	2—2·5	2·8—2·9	Sol. eas.	Fus.
232	Borzeliite	Mass.	5·5	2·52	Sol. n.	Infus.
	V. Rock Salt.					
233	Rock Salt ...	Tess.	2	2·1—2·2	Sol. wtr. !!	Fus.
234	Alum	Tess.	2—2·5	1·75—1·9	Sol. wtr. !!	Sul. fms.
235	Alunogene ...	?	1·5—2	1·6—1·7	Sol. wtr. !!	Infus.
236	Glauber Salt	Mncl.	1·5—2	1·4—1·5	Sol. wtr. !!	Fus. hep.
237	Melanterite ...	Mncl.	2	1·8—1·9	Sol. wtr. !!	Fus. evap.
238	Botryogene ...	Mncl.	2—2·5	2—2·1	Sol. wtr. imp.	Int.
239	Copiapite	Cryst.	...	...	Sol. wtr.	...
240	Coquimbite ...	Hex.	2—2·5	2—2·1	Sol. wtr.	Sul. fms.
241	Tectizite	Rhm.	1·5—2	2	Sol. wtr. !	Fus.
242	Cyanose	Trcl.	2·5	2·2—2·3	Sol. wtr. !	Red. Cu.
243	Goslarite	Rhm.	2—2·5	2—2·1	Sol. wtr. !!	Int.
244	Bieberite	Mncl.	...	...	Sol. wtr.	Sul. fms.
245	Johannite.....	Mncl.	2—2·5	3·19	Sol. wtr.	
246	Natron.....	Mncl.	1—1·5	1·4—1·5	Sol. wtr.	Ef. with sil.
247	Thermonatrite	Rhm.	1·5	1·5—1·6	Sol. wtr.	Ef. with sil.
248	Trona	Mncl.	2·5—3	2·1—2·2	Sol. wtr.	Ef. with sil.
249	Gaylussite ...	Mncl.	2·5	1·9—2	Sol. wtr. imp.	Fus. eas.
250	Borax	Mncl.	2—2·5	1·7—1·8	Sol. wtr.	Intm. fus.
251	Sassoline	Trcl.	1	1·4—1·5	Sol. wtr.	Frth. fus.
252	Nitre	Rhm.	2	1·9—2	Sol. wtr.	Fus. ! cl. fl.
253	Nitratine	Rhdr.	1·5—2	2·1—2·2	Sol. wtr.	Fus. ; cl. fl.
254	Nitrocalcite...	Fibr.	...	...	Sol. wtr.	Fus. eas.
255	Nitromagnesite	Fibr.	...	...	Sol. wtr.	Fus. eas.
256	Sal-ammoniac	Tess.	1·5—2	1·5—6	Sol. wtr. !	Vol.
257	Mascagnine ...	Rhm.	2—2·5	1·7—1·8	Sol. wtr. !	Dcr. fus. vol.
258	Arcanite	Rhm.	2·5—3	1·73	Sol. wtr.	Dcr. fus. cryt.
259	Thenardite ...	Rhm.	2·5	2·6—2·7	Sol. wtr.	Fus. cl. fl.
260	Epsomite	Rhm.	2—2·5	1·7—1·8	Sol. wtr. !	Fus.

III. ORDER.—SALINE ORES.

	Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
	I. Fam. Sparry Iron Ores.					
261	Siderite	Rhdr.	3·5—4·5	3·7—3·9	Sol. ef.	Inf. bkns. mag.
262	Ankerite	Rhdr.	3·5—4	2·9—3·1	Sol. ef.	Inf. bkns. mag.
263	Diallogite	Rhdr.	3·5—4·5	3·3—3·6	Sol. ef. w. h.	Inf. dcr.
264	Manganocalcite	Rhm.	3·5—4·5	3·3—3·6	Sol. ef.	Inf.
265	Lanthanite	Tet.	2·5—3	. .	Sol. ef.	Inf.
266	Parisite	Hex.	4·5	4·35	.....	Inf. phos.
267	Calamine	Rhdr.	5	4·1—4·5	Sol. ef.	Infus.
268	Galmei	Rhm.	5	3·3—3·5	Sol. ; sil. gel.	Dcr. inf.
269	Williamite	Rhdr.	4·5	4·1—4·2	Sol.	Dcr. inf.
270	Triplite	Rhm.	5—5·5	3·6—3·8	Sol. h.	Fus. intm.
271	Zwieselite	Rhm.	4·5—5	3·9—4	Sol. w. s.	Dcr. fus.
272	Triphyline	Rhm.	4—5	3·5—3·6	Sol. h. eas.	Fus. mag.
273	Hureaulite	Mncl.	3·5	2·27	Sol.	Fus. eas.
274	Heterozite	Rhm. ?	4·5—5·5	3·4—3·5	Sol. h.	Fus.
275	Alluaudite	Rhm.	4—	3·4—3·5	Sol. h.	Fus. mag.
276	Pitticite	Amor.	2—3	2·3—2·5	Sol. h.	Fus. ef.
277	Diadochite	Mass.	3	2·03	.. ...	Fus. dif.
	II. Copper-Salts.					
278	Dioptase	Rhdr.	5	3·2—3·3	Gel. h. s.	Inf. cl. fl.
279	Chrysocolla	Mass.	2—3	2·0—2·3	Gel. h. s.	Inf. cl. fl.
280	Azurite	Mncl.	3·5—4	3·7—3·8	Sol. ef.	Fus. red.
281	Malachite	Mncl.	3·5—4	3·6—4	Sol. ef.	Fus. red.
282	Aurichalcite	Acic.	2	...	Sol. ef.	Zn. Cu.
283	Chalcophyllite	Rhdr.	2	2·4—2·6	Sol. eas.	Dcr. fus.
284	Tirolite	Mass.	1·5—2	3—3·1	Sol. ef.	Dcr. !! fus.
285	Erinite	Amor.	4·5—5	4—4·1	.....	.....
286	Liroconite	Rhm.	2—2·5	2·8—3	Sol.	Fus. intm.
287	Olivenite	Rhm.	3	4·2—4·6	Sol.	Fus. eas. Ar.
288	Euchroite	Rhm.	3·5—4	3·3—3·5	Sol. n. eas.	Fus. Ar.
289	Klinoclase	Mncl.	2·5—3	4·2—4·4	Sol. ac.	Red. Cu.
290	Phosphorochalcite	Mncl.	5	4·1—4·3	Sol. n. eas.	Fus. dcr.
291	Thrombolite	Amor.	3—4	3·3—3·4	.....	Fus. cl. fl.
292	Libethenite	Rhm.	4	3·6—3·8	Sol. n. eas.	Fus.
293	Tagilite	Amor.	4	3·5	.....	.....
294	Ehlite	Mass.	1·5—2	3·8—4·3	Sol. n. eas.	Fus. dcr.
295	Atacamite	Rhm.	3—3·5	4—4·3	Sol. eas.	Fus. cl. fl.
296	Volborthite	Hex.	3	3·55	Sol. h. n.	Fus. eas.
297	Arseniosiderite	Fibr.	1—2	3·5—3·9	... .	Fus. eas.
298	Pharmakosiderite	Tess.	2·5	2·9—3	Sol. eas.	Fus. Ar. mag.
299	Scorodite	Rhm.	3·5—4	3·1—3·2	Sol. h. eas.	Fus. Ar. mag.
300	Symplesite	Mncl.	2·5	2·9—3	.....	Inf. Ar. mag.
301	Brochantite	Rhm.	3·5—4	3·7—3·9	Sol. eas.	Fus. Cu.
302	Vivianite	Mncl.	2	2·6—2·7	Sol. h. n. eas.	Fus. mag.
303	Dufrénite	Rhm. ?	3—3·5	3·3—3·4	Sol. h.	Fus. eas.

NAME.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
304 Uranite	Tet.	1—2	3—3·2	Sol. n.	Fus.
305 Chalcolite	Tet.	2—2·5	3·5—3·6	Sol. n.	Fus.
306 Erythrine.....	Mncl.	2·5	2·9—3	Sol. eas.	Fus. Ar. Co.
307 Nickeline.....	Trcl. ?	2—2·5	3—3·1	Sol. eas.	Fus. Ar. Ni.
III. LEAD-SALTS.					
308 Cerussite	Rhm.	3—3·5	6·4—6·6	Sol. n. ef.	Dcr. Pb.
309 Anglesite.....	Rhm.	3	6·2—6·3	Sol. dif.	Dcr. fus. Pb.
310 Leadhillite	Mncl.	2·5	6—6·4	Sol. n. ef.	Intm. red. Pb.
311 Lanarkite.....	Mncl.	2—2·5	6·8—7	Sol. n. ef. imp.	Fus.
312 Caledonite	Rhm.	2·5—3	6·4	Sol. n.	Red. Pb.
313 Linarite	Mncl.	2·5—3	5·3—5·5	.....	.....
314 Phosgenite	Tet.	2·5—3	6—6.2	Sol. n. ef.	Fus. red. Pb.
315 Mendipite	Rhm.	2·5—3	7—7·1	Sol. n. eas.	Fus. red.
316 Corunnite.....	Rhm.	...	5·23	Sol.	Fus. cl. fl.
317 Pyromorphite ...	Hex.	3·5—4	6·9—7	Sol. n.	Fus. eas.
318 Mimetesite	Hex.	3·5—4	7·2—7·3	Sol. n.	Fus.
319 Bleinierite	Amor.	4	3·9—4·7	Sol.	Red. Pb.
320 Vanadinite	Hex.	3	6·8—7·2	Sol. n. eas.	Dcr. fus. red.
321 Wulfenite	Tet.	3	6·3—6·9	Sol. w. n.; h. s.	Dcr. fus. red.
322 Scheelitine	Tet.	3	7·9—8·1	Sol. n.	Fus.
323 Plombgomme ...	Mass.	4—4·5	6·3—6·4	Sol. n.	Intm. fus. imp.
324 Crocoisite..	Mncl.	2·5—3	5·9—6·1	Sol. w. h.; n.	Dcr. fus. red.
325 Melanochroite...	Rhm.	3—3·5	5·75	Sol. h.	Fus.
326 Vauquelinite ...	Mncl.	2·5—3	5·5—5·8	Sol. n. imp.	Intm. fus.
327 Bismuthite	Mass.	4—4·5	6·8—6·9	Sol. h.	Dcr. fus. ef.
328 Kerate	Tess.	1—1·5	5·5—5·6	Af. imp.	Fus. red. Ag.
329 Calomel	Tet.	1—2	6·4—6·5	Sol. ncl.	Vol.
330 Iodite	Fol.	1—1·5	5·5	Sol. con. n. h.	Fus. eas. red.
331 Coccinite	...	...	...	.....	Fus. eas. sub.
332 Bromite	Tess.	1—2	5·8—6	Af. imp. !!	.....
333 Romëite	Tet.	...	...	Insol.	Fus. slag.
334 Scheelite	Tet.	4—4·5	5·9—6·2	Sol. h. n. imp.	Fus. dif.

IV. ORDER.—OXIDIZED ORES.

I. FAM. OXIDIZED IRON ORES.					
335 Magnetite	Tess.	5·5—6·5	4·9—5·2	Sol. h.	Fus. dif. !!!
336 Chromite.....	Tess.	5·5	4·4—4·5	Af. dif. !!!	Inf. mag.
337 Franklinite	Tess.	6—6·5	5—5·3	Sol. h.	Inf. incan.
338 Hæmatite	Rhdr.	5·5—6·5	5·1—5·3	Sol. dif.	Bkns. mag.
339 Irite.....	Fol.	...	6·5	Insol.	.....
340 Limonite.....	Mass.	5—5·5	3·4—4	Sol. h. eas.	Fus. dif. !! mag.
341 Götheite	Rhm.	5—5·5	3·8—4·4	Sol. h.	Fus. dif.
342 Ilmenite	Rhdr.	5—6	4·6—5	Sol. dif. h. ncl.	Inf.
343 Iserine..	Tess.	6—6·5	4·7—4·9	Sol. dif. h. ncl.	Inf.
II. TIN ORE.					
344 Cassiterite	Tet.	6—7	6·3—7	Insol.	Inf. (red. St.)

Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
345 Wolfram	Mncl.	5—5·5	7·1—7·5	Sol. w. h.	Fus. mag.
346 Columbite	Rhm.	6	5·4—6·4	Insol.	Infus.
347 Tantalite	Rhm.	6—6·5	7·1—8	Af. dif. !!!	Inf.
348 Yttrotantalite ..	?	5—5·5	5·4—5·8	Insol.	Inf. brown.
349 Euxenite	Rhm.	6·5	4·6	Insol.	Inf.
350 Fergusonite	Tet.	5·5—6	5·8—5·9	.....	Inf.
351 Sphene.....	Mncl.	5—5·5	3·4—3·6	Sol. s.; h. imp.	Int. fus. dif.
352 Brookite	Rhm.	5·5—6	4·1—4·2	Insol.	Inf.
353 Rutile	Tet.	6—6·5	4·2—4·3	Insol.	Inf.
354 Anatase	Tet.	5·5—6	3·8—4	Sol. w. con. s.	Inf.
354α Pechurane	Amor.	5·5	6·4—8	Sol. w. n. ncl.	Inf.
355 Plattnerite	Hex.	...	9·3—9·5	.....	... ..
III. Manganese Ores.					
356 Pyrolusite	Rhm.	2—2·5	4·7—5	Sol. h.	Infus.
357 Polianite	Rhm.	6·5—7	4·8—4·9	Sol. h.	Infus.
358 Manganite	Rhm.	3·5—4	4·3—4·4	Sol. w. h.	Infus.
359 Hausmannite ...	Tet.	5·5	4·7—4·8	Sol. h.	Inf.
360 Braunite	Tet.	6—6·5	4·8—4·9	Sol. h.	Inf.
361 Psilomelane.....	Amor.	5·5—6	4·1—4·2	Sol. s. red.	Inf.
362 Crednerite	Mncl.	4·5—5	4·8—5·1	Sol. ncl. green.	Inf. exf.
363 Cupreous manganese	Amor.	3·5	3·1—3·2	.....	Fus. Cu.
364 Earthy cobalt ...	Amor.	1—1·5	2·1—2·2	.....	Inf.
365 Wad.....	Mass.	3	2·3—3·7	Sol. h.	Inf.
Ochres.					
366 Cobalt Ochre ...	Amor.	1—2	2—2·7	.....	Fus.
367 Molybdena O....	Amor.	...	...	Sol. h.	Fus.
368 Bismuth O.....	Amor.	...	4·3—4·7	Sol. h.	Red.
369 Antimony O. ...	Amor.	Soft	3·7—3·8	.....	Not red.
370 Tungsten O.. ...	Earthy.	Soft	...	Sol. am.	Bkns.
371 Uranium O.....	Mass.	Soft	...	Sol. eas.	Inf. green.
372 Minium	Mass.	2—3	4·6	Sol. n.	Fus. red. Pb.
373 Lead Ochre.....	Mass.	...	8·0	.....	Fus. red.
374 Chrome O.	Mass.	...	...	Sol. potash.	Inf.
375 Tellurite	Mass.	...	...	.....	... ..
IV. Red Copper Ores.					
376 Cuprite	Tess.	3·5—4	5·7—6	Sol. h. n.	Fus. Cu..
377 Chalcotrichite ...	Rhdr.	...	5·8	Sol. h. n.	Fus. Cu.
378 Tenorite	Hex.	...	...	.....	.....
379 Zincite.....	Hex.	4—4·5	5·4—5·5	Sol. ac.	Inf. phos.
V. White Antimony Ores.					
380 Valentinite	Rhm.	2·5—3	5·5—5·6	Sol. h. eas.	Fus. eas. !!
381 Arsenite	Tess.	1·5—3	3·6—3·7	Sol. wtr. dif.	Vol.

III. ORDER.—NATIVE METALS.

ONLY ONE FAMILY.

	Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe.
382	Platina	Tess.	4—5	17—19	Sol. ncl.	Fus. dif. !!!
383	Palladium	Tess.	4·5—5	11·8—12·2	Sol. n.	Inf.
384	Osmiumiridium	Hex.	7	19·3—21·2	Insol.	Inf.
385	Iridium	Tess.	6—7	22—23	Insol.	Inf.
386	Gold	Tess.	2·5—3	17—19·4	Sol. ncl.	Fus. dif.
387	*Silver*	Tess.	2·5—3	10—11·1	Sol. n. eas.	Fus. eas.
388	Antimony-silver	Rhm.	3·5	9·4—9·8	Sol. n.	Fus. fms.
389	Mercury	Tess.	fluid	13·5—13·6	Sol. con. n.	Vol.
390	Amalgam	Tess.	3—3·5	13·7—14	Sol. n. eas.	Vol. Hg. Ag.
391	Antimony	Rhdr.	3—3·5	6·6—6·8	Sol. ncl. ef.	Fus. fms.
392	Arsenic-Antimony	Rhdr.	3·5	6·1—6·2		Fms.
393	Arsenic	Rhdr.	3·5	5·7—5·8	Sol. n. ncl.!!	Fus. eas.
394	Tellurium	Hex.	2—2·5	6·1—6·3	Sol. n.	Fus. eas.
395	Lead	Tess.	1·5	11·3—11·4	Sol. n.	Fus. eas.
396	Tin (?)	...	...	...	.....	.....
397	Bismuth	Tess.	2·5	9·6—9·8	Sol. n.	Fus. eas.
398	Copper	Tess.	2·5—3	8·5—8·9	Sol. n.	Fus. eas.
399	Iron	Tess.	4·5	7—7·8	Sol. h.	Inf.

VI. ORDER.—SULPHURETTED METALS.

	I. FAM. PYRITES.					
400	Pyrite	Tess.	6—6·5	4·9—5·1	Sol. n.	Fms. fus.
401	Marcasite	Rhm.	6—6·5	4·6—4·9	Sol. n.	Fms. fus.
402	Pyrrhotine	Hex.	3·5—4·5	4·4—4·7	Sol. h.	Fus. mag.
403	Leucopyrite	Rhm.	5—5·5	7·1—7·4	Sol. n.	Fus. mag.
404	Mispickel	Rhm.	5·5—6	6—6·2	Sol. n.	Fus. mag.
405	Cobaltine	Tess.	5·5	6—6·1	Sol. w. n.	Fus.
406	Smaltine	Tess.	5·5	6·4—7·3	Sol. n.	Fus. eas.
407	Modumite	Tess.	6	6·7—6·9	Sol. n.	Fus. eas. sub.
408	Linnëite	Tess.	5·5	4·9—5	Sol. w. n.	Fus. mag.
409	Grünauite	Tess.	4·5	5·1—5·2	Sol. n.	Fus. mag.
410	Gersdorffite	Tess.	5·5	6—6·6	Sol. n. imp.	Fus. fms. !
411	Ullmannite	Tess.	5—5·5	6·2—6·5	Sol. con. n.	Fus. fms. !!
412	Breithauptite	Hex.	5	7·5—7·6	Sol. ncl. eas.	Fms. fus. dif.
413	Plakodine	Rhm.	5—5·5	7·9—8·1	Sol. n.	Fus. eas. fms.
414	Nickeline	Hex.	5·5	7·5—7·7	Sol. con. n.	Fus. fms. !!
415	Rammelsbergite	Tess.	5·5	6·4—6·6	Sol. con. n.	Fus. eas.
	Chloanthite	Rhm.	5·5	7—7·2	Sol. con. n.	Fus. eas.
416	Millerite	Rhdr.	3·5	5·2—5·3	Sol. ncl.	Fus. eas.
417	Eisennickelkies	Tess.	3·5—4	4·6	.....	Fus. mag.
418	Chalcopyrite	Tet.	3·5—4	4·1—4·3	Sol. ncl.	Fus. eas.
419	Bornite	Tess.	3	4·9—5·1	Sol. con. h.	Fus. eas.
420	Domeykite	Mass.	3—3·5	...	Insol. h.	Fus. eas.

Name.	Crystallization.	Hardness.	Specific Gravity.	Acids.	Blowpipe.
421 Arseniate of manganese	Mass.	...	5·55	Sol. nel.	Fms. burns.
II. Lead Glance.					
422 Galena.....	Tess.	2·5	7·4—7·6	Sol. n.	Dcr. fus. red.
423 Cuproplumbite...	Tess.	2·5	6·4—6·5		Fus. eas.
424 Clausthalite...	Tess.	2·5—3	8·2—8·8	Sol. n.	Fms. Se. vol.
425 Selencopperlead	Mass.	2·5	7—7·5	Sol. n.	Fms. fus.
426 Onofrite	Mass.	2.5	7·3	Insol. n.	Vol.
427 Naumannite	Mass.	2·5	8	Sol. con. n. eas.	Fus.
428 Argentite.....	Tess.	2—2·5	7—7·4	Sol. con. n. S.	Fus. int. red.
429 Stromeyerite	Rhm.	2·5—3	6·2—6·3	Sol. n. S.	Fus. eas.
430 Redruthite ...	Rhm.	2·5—3	5·5—5·8	Sol. w. n. S.	Fus. sput.
431 Kupferindig..	Hex.	1·5—2	3·8—3·9	Sol. n.	Burns. fus.
432 Eukairite	Cryst.	Soft.	...	Sol. n.	Fus. fms.
433 Berzeline	Cryst.	Soft.	...	.....	Fus. Se.
434 Nagyagite ...	Tet.	1—1·5	6·8—7·2	Sol. n. Au.	Fus. fms. Au.
435 Altaite.....	Tess.	3—3·5	8·1—8·2	Sol. n. eas.	Fus. vol.
436 Hessite.....	Mass.	2·5—3	8·3—8·9	Sol. w. n.	Fms. Ag.
437 Tetradymite	Rhdr.	1—2	7·4—8·5	Sol. n.	Fus. eas.
438 Molybdenite	Hex.	1—1·5	4·6—4·9	Sol. w. s. ncl.	Inf. brns.
III. Grey Antimony Ores.					
439 Stibine.....	Rhm.	2	4·6—4·7	Sol. w. h. ; n.	Fus. eas.
440 Jamesonite ...	Rhm.	2—2·5	5·5—5·7	Sol. w. h.	Dcr. fus. vol.
441 Zinckenite ...	Hex.	3—3·5	5·3—5·35	Sol. w. h.	Dcr. ! ! fus. vol.
442 Plagionite ...	Mncl.	2·5	5·4	Sol. w. h.	Dcr. ! ! fus. red.
443 Boulangerite	Mass.	3	5·8—6	Sol. n. imp.	Fus. eas. fms.
444 Geokronite ...	Rhm.	2—3	6·4—6·5	Sol. h.	Fus. eas. vol.
445 Steinmannite	Tess.	2·5	6·8—6·9	.....	Dcr. ! fus. eas.
446 Plumosite ...	Acic.	1—3	5·7—5·9	Sol. w. h.	Fus. eas. !
447 Dufrénoysite	Tess.	...	5·55	Sol. w. n.	Fus. eas.
448 Wolfsbergite	Rhm.	3·5	4·75	.....	Dcr. fus. fms.
449 Kermes	Mncl. ?	1—1·5	4·5—4·6	Sol. h.	.....
450 Berthierite ...	Mass.	2—3	4—4·3	Sol. h. ncl.	Fus. fms.
451 Bismuthine ...	Rhm.	2—2·5	6·4- 6·6	Sol. n.	Fus. sput.
452 Aciculite	Rhm.	2·5	6·7—6·8	Sol. n.	Fus. eas. fms.
453 Kobellite	Mass.	Soft.	6·3	Sol. con. h.	Fus. red.
454 Sylvanite	Rhm.	1·5—2	8—8·3	Sol. ncl.	Fus. red. Au.
IV. Grey Copper Ore.					
455 Fahlore	Tess.	3—4	4·3—5·2	Sol. n.	Fus. mag.
456 Tennantite ...	Tess.	4	4·3—4·5	Sol. n. green.	Dcr. fus. mag.
457 Bournonite ..	Rhm.	2·5—3	5·7—5·9	Sol. n. blue.	Dcr. fus.
458 Wölchite	Rhm.	3	5·7—5·8	.....	Fus. ef.
459 Freieslebenite	Rhm.	2—2·5	6—6·4	.....	Fms. red. Ar.
460 Stephanite ...	Rhm.	2—2·5	6·2—6·3	Sol. w. n.	Fus. red. Ar.
461 Polybasite ...	Hex.	2—2·5	6—6·25	Sol. n.	Dcr. fus. eas.
462 Sternbergite...	Rhm.	1—1·5	4·2—4·3	Sol. ncl.	Fus. mag. Ar.

	Name.	Crystallization.	Hardness.	Specific gravity.	Acids.	Blowpipe
463	Stannine	Tess.	4	4·3—4·5	Sol. n. blue.	Fus. dif.
464	Cupreous Bismuth ...	Rhm.	3·5	5	Sol. n. S.	Fus. eas. frth.
465	Bismuthic Silver	Acic.	Soft.	...	Sol. n.	Fus. eas.
	V. Blendes.					
466	Blende	Tess.	3·5—4	3·9—4·2	Sol. con. n.	Dcr.! fus. dif.!!
467	Woltzine	Mass.	4·5	3·66	Sol. h.	Dcr. fus. dif. !
468	Alabandine	Tess.	3·5—4	3·9—4	Sol. h.	Fus. dif. !!
469	Hauerite	Tess.	4	3·46	Sol. h.	.....
470	Greenockite.....	Hex.	3—3·5	4·8—4·9	Sol. h.	Dcr.
	VI. Ruby Blendes.					
471	Pyrargyrite	Rhdr.	2—2·5	5·5—5·8	Sol. n.	Fus. eas. fms.
472	Miargyrite	Mncl.	2—2·5	5·3—5·4	Sol. n.	Fus. red. Ar.
473	Xanthokon	Rhdr.	2—2·5	5—5·2	Sol. n.	Fus. fms. Ar.
474	Cinnabar	Rhdr.	2—2·5	8—8·2	Sol. ncl.	Subl.
475	Realgar	Mncl.	1·5—2	3·4—3·6	Af. dif.	Fus. brns.
476	Orpiment..... ..	Rhm.	1·5—2	3·4—3·5	Sol. ncl.	Subl. brns.

VII. ORDER.—THE INFLAMMABLES.

	I. Fam. Sulphur.					
477	Sulphur	Rhm.	1·5—2·5	1·9—2·1		
478	Selen-sulphur ...	...	...	...		
	II. Diamond.					
479	Diamond	Tess.	10	3·5—3·6		
	III. Coals.					
480	Graphite	Hex.	0·5—1	1·9—2·2		
481	Anthracite	Amor.	2—2·5	1·4—1·7		
482	Common Coal ...	Comp.	2—2·5	1·2—1·5		
483	Brown Coal	Comp.	...	0·5—1·5		
484	Peat.....	Amor.	...	...		
	IV. Mineral Resins.					
485	Bitumen	Fluid.	...	0·7—0·9		
486	Elaterite	Comp.	Soft.	0·8—1·23		
487	Asphaltum	Comp.	2	1·1—1·2		
488	Piauzite	Comp.	1·5	1·22		
489	Ixolyte	Amor.	1	1·008		
490	Amber	Amor.	2—2·5	1—1·1		
491	Retinite	Amor.	1·5—2	1—1·15		
492	Walchowite... ..	Amor.	1·5—2	1·03—1·07		
493	Copaline	Amor.	1·5	1·046		
494	Berengelite	Amor.	...	...		
495	Guyaquillite.....	Amor.	...	1·092		
496	Hartine	Amor.	...	1·115		

	Name.	Crystallization.	Hardness.	Specific Gravity.	Acids.	Blowpipe.
497	Middletonite ...	Amor.	...	1·6		
498	Ozokerite.....	Amor.	..	0·94—0·97		
499	Hatchetine	Amor.	...	0·6		
500	Fichtelite.....	Cryst.	...			
501	Hartite.....	Mass.	1	1·046		
502	Könlite	Mass.	...	0·88		
503	Scheererite	Mncl.	...	1—1·2		
504	Idrialite	Mass.	1—1·5	1·4—1·6		
	V. Inflammable Salts.					
505	Mellite.....	Tet.	2—2·5	1·4—1·8	Sol. n.	White, Äi.
506	Oxalate	Acic.	2	2·1—2·3	Sol. eas.	Red ash.

MANUAL OF MINERALOGY.

INTRODUCTION.

The proper object of Natural History is the investigation and systematic description of the numerous individual objects that compose the material world, so far as these can be known from observation or experiment. For this purpose it endeavours to classify or combine the immense variety of natural productions into groups of more or less extent, and distinguished by certain definite characteristics. The first great natural division that appears in this process of classification is into organic and inorganic bodies. The former are distinguished by possessing organs, that is, instruments for the performance of certain functions, and consequently a compound frame, the various parts of which are not uniform, but different in structure, in chemical composition, and mode of aggregation. The inorganic products of nature, on the contrary, present no distinction of parts, no organs with definite functions; but each individual, so far as it is mechanically separable, consists of parts uniform in composition and state of aggregation. The former class also exhibit a union of solid and fluid substances, are endowed with internal powers of motion, are fitted to pass through a particular series of changes, are destined to endure only for definite periods, and preserve the species by a succession of similar individuals. The latter are either homogeneous in every part, or mere aggregates of bodies that are so; they have no internal principle of motion, no definite period of existence, no regular series of changes, and no peculiar arrangement for continuing the species, when the individual perishes. In external form these two departments of nature also widely differ; organic bodies being bounded by curved lines and rounded surfaces,—the inorganic generally by straight lines

and planes; often, however, very irregularly disposed. Organic beings, too, usually consist of more complex and apparently less definite chemical compounds, than the inorganic, but these intimately united and rendered distinctly one by the principle of life. Hence each individual exists more isolated and independent, and has its form and magnitude more precisely determined by the primary idea of the species than appears to be the case in the inorganic world.

Each of these departments of nature must be again divided. The organic world forms the two great divisions of the vegetable and animal kingdoms, the subjects of the sciences of Botany and Zoology. The divisions of inorganic bodies are less definite and precise, and the sciences treating of them are more often confounded. Natural history can take notice of them only as individual objects, resigning the description of them as mere substances to chemistry, and the account of many of their other properties and phenomena to general physics. In this respect the science of inorganic nature only follows the same course with botany and zoology. Like these it borrows from chemistry and physics such facts as are necessary to characterize the objects of its consideration, or to elucidate their true nature as individuals; but it at the same time claims for itself an independent domain, and cannot justly, any more than zoology or botany, be merged into a mere section of chemical science. The confusion of these two sciences must prove injurious to both, leading chemistry away from its true object on the one hand, and, on the other, causing the neglect of many important branches of the natural history of the inorganic world. The latter has now grown up into several independent, though closely-connected sciences. Of these Mineralogy is properly the science of simple minerals, that is, of those natural products which possess a certain definite form and composition. Geognosy again considers these minerals, as, united in large masses, they form those rocks of which the crust of the globe is built up, and gives an account of their relative position, age, and probable mode of origin. The ocean and atmosphere would be included in this division of natural history, were not their phenomena so varied and important, as to require that they should be rather regarded as independent departments of natural history. A still wider field is opened for Geology, which, viewing the earth as a whole, and searching out the laws that regulate the succession of phenomena on its surface, endeavours from the consideration of the present to unravel the history of the past, to form some probable conjectures in reference to that of the future. Properly speaking, therefore, geology is not a mere branch of the natural history of the inorganic or mineral kingdom; but is the highest result of the study of nature as a whole,—the systematic combination of the most general

laws to which the mineral, the vegetable, and animal kingdoms are or have been subject, and a combined view of the various revolutions which, in obedience to these, or still higher laws, the material system of nature may have undergone.

Mineralogy being thus limited to the natural history of simple minerals, it becomes necessary to define what is to be understood by this term. In the strictest sense, a mineral species is a natural inorganic body, possessing a definite chemical composition, and assuming a regular determinate form or series of forms. This definition will exclude many bodies often included in the mineral kingdom. Thus, all the artificial salts of the chemists, all the inorganic secretions of plants and animals, all the remains of former living beings now imbedded in rocks, are excluded from the consideration of the mineralogist. Some substances, originally organic products, have indeed by common consent found a place in mineral systems, as coal, amber, and mineral resins; but this is a departure from the strictness of the definition, and in most cases had perhaps better have been avoided. So also some amorphous substances, with no precise form or chemical composition, as some kinds of clay, have been introduced into works on mineralogy, but we believe often improperly, and with no beneficial result. Aggregates of simple minerals or rocks are likewise excluded from this science, though the various associations of minerals, their modes of occurrence, and their geological position, are important points in the history of the different species. There are, however, certain limitations with which the above definition must be understood, which will be subsequently pointed out.

One most important object of a treatise on mineralogy should be to give such descriptions of minerals, their essential properties and distinctive characters, as will enable the student to distinguish the various species, and to recognise them when they occur in nature. But to accomplish this he must first become acquainted with the Terminology or nomenclature of the science, that is, with the meaning of the terms used in describing these properties, and the various modifications they may undergo. With this is necessarily conjoined an account of these properties themselves, and of the more general laws by which their various changes are regulated. A second and closely-related portion of mineralogy is the System or Classification, giving an account of the order in which the species are arranged, and the reasons for which it has been adopted. The third and most important part of mineralogy, to which these two are properly preparatory, is the Physiography of the various species, giving an account of their characteristic marks, and a description of their appearance, or external aspect and forms; their principal physical and chemical properties; their mode of occur-

rence, with their geological and geographical distribution; and their various uses, whether in nature or in the arts. Each of these departments will be considered in the following Manual in the order just mentioned, and with such fulness as their relative importance and the limits of the work will permit.

PART I.—TERMINOLOGY.

CHAP. I.—FORM OF MINERALS.

By the physical properties of a mineral as opposed to the chemical, is to be understood, all those properties belonging to it as a body existing in space, and consisting of matter aggregated in a peculiar way. To this division of the subject, therefore, belongs the consideration of its form as shown in crystallization; its structure as determining its mode of cleavage and fracture; its hardness and tenacity; its weight or specific gravity; and its various optical, electrical, magnetic, and other similar properties.

Crystalline and Amorphous.—Mineral substances occur in two distinct modes of aggregation. Some consist of parts evidently arranged according to a definite law, whilst in the formation of others no such law appears to have been in operation. Their minute particles are simply collected together, and exhibit no regularity of structure or constancy of external form, and are, therefore, named amorphous. All fluid minerals are of course in this condition, together with some solid bodies, which appear to have condensed either from a gelatinous condition like opal, when they are named *porodine*, or from a state of igneous fluidity like obsidian and glass, when they are named *hyaline*. It may be doubted, however, how far any mineral body is truly amorphous, as the optical properties of many that are apparently so seem to depend on some peculiar and determinate structure, though too minute to be distinguished. The other class of bodies are named *crystalline*, when the regularity of structure appears only in the internal disposition of the parts; and *crystallized*, when it also produces a determinate external form, or a *crystal*. A familiar example of crystalline structure is seen in a piece of loaf sugar, the broken surface of which presents innumerable minute polished planes, from which the light is reflected.

Faces, edges, angles, axes of Crystals.—The word *crystal* in mineralogy designates a solid body exhibiting an original (not artificial) more or less regular polyhedric form. It is thus bounded by plane

surfaces, named *faces*, which intersect in straight lines or *edges*, and these again meet in points and form *angles*, which, when bounded by three or more faces, are named *solid angles*. The space occupied by a crystal, and bounded by its faces, is often named a *form of crystallization*, which is thus merely the mathematical figure regarded as independent of the matter that fills it. Some crystals are bounded by equal and similar faces, and are named *simple forms;* whilst those in which the faces are not equal and similar are named *compound forms*, or *combinations*, being regarded as produced by the union or combination of the faces of two or more simple forms. The cube or hexahedron (fig. 1), bounded by six equal and similar squares; the octahedron (fig. 2), by eight equilateral triangles; and the rhombohedron, by six rhombs,—are thus simple forms. The *axis* of a crystal is a line passing through its centre and terminating either in the middle of two faces, or of two edges, or in two angles; and axes terminating in similar parts of a crystal are named similar axes. In describing a crystal one of its axes is supposed to be vertical or upright, and is then named the *principal axis*. A few other technical terms used in describing crystals, or the modifications they undergo, will be better explained as they occur. Those terms which are found in every elementary treatise on geometry, as line, angle, circle, need not be defined here, as we may suppose that our readers possess so much of the rudiments of that science as is required for this purpose. The higher branches of crystallography, indeed, require considerable acquaintance with mathematics and practical skill in calculation; but to understand the following treatise, a very moderate knowledge of the elementary principles of geometry will suffice.*

Systems of Crystallization.—The forms of crystals that occur in nature seem almost innumerable; and unless some general laws by which they are regulated had been discovered, the attempt to name and describe them might have been deemed hopeless. On examining them, however, more attentively, it is soon discovered that the various faces, even in the more complex crystals, are disposed in a symmetrical manner. When the axes of the crystals are properly chosen, and placed in a right position, the various faces are observed to group themselves in a regular and beautiful manner around these axes, and to be all so related to them as to compose a connected series produced

* The beginner will find much advantage in procuring models of the forms of simple crystals described in the following pages, or still better by preparing them for himself from some soft material, as clay, chalk, or wood. Very instructive models may also be made of pasteboard, the faces of the crystals being cut out of the proper form and glued together; or they may be made of glass, and one inclosed in another, so as to represent the connection of the different forms, and the manner in which they are derived from each other. Such models give far clearer notions of solid bodies than engravings on a flat surface, in which their three dimensions can be but imperfectly represented.

according to definite laws, It appears that in every mineral species there is a certain form of crystal, with axes intersecting at fixed angles, and bearing to each other definite proportions, from which, as a primary, every other form of crystal observed in that mineral species may be deduced, simply by varying the proportions of these axes. It is found that in each species the axes intersect each other at angles which are constant, and that the angles formed by the intersection of the faces are also related to each other according to certain definite laws. When viewed in this manner, and referred to their simplest forms, it is seen that the innumerable variety of crystals occurring in nature may all be reduced to six distinct groups, or, as they are named, systems of crystallization.* To these various names have been assigned by different authors, but the following are those of most importance, placed in parallel columns.

Systems of crystallization according to

Naumann.	*Mohs.*	*Weiss and G. Rose.*
1. Tesseral System.	Tessular.	Regular.
2. Tetragonal System.	Pyramidal.	2 and 1 axial.
3. Hexagonal System.	Rhombohedral.	3 and 1 axial.
4. Rhombic System.	Orthotype.	1 and 1 axial.
5. Monoclinohedric System.	Hemiorthotype.	2 and 1 membered.
6. Triclinohedric System.	Anorthotype.	1 and 1 membered.

Some authors conjoin the last three systems in one; the rhombic of Breithaupt, the trimetric of Hausmann; but as they must again distinguish them in detail, it is better to divide them at first. In the following treatise the terminology of Naumann is adopted, his method of classifying and describing crystals appearing the simplest, and best adapted to promote the progress of the student.

The first, or *Tesseral System*, is characterised by three equal axes intersecting each other at right angles. Its forms thus present a greater degree of regularity and equality than any of the other systems, and hence Weiss has named it the regular, and Hausmann the isometric system, whilst the name hereeused is taken from tessera, a cube, which is one of its most frequent varieties. Properly speaking, this system has no chief axis, as any one of them may be so named, and placed upright in drawing and describing the crystals. Of these there are thirteen varieties, which are thus classed and named from the number of their faces:—

1. One Tetrahedron, or form with four faces.
2. One Hexahedron, with six faces.
3. One Octahedron, with eight faces.

* There is a seventh system possible, and actually met with in one variety of an artificial salt, but as it does not occur in any mineral, we need not delay to consider it further. Naumann, in conformity to his method, names it the diclinohedric.

4. Four Dodecahedrons, with twelve faces.
5. Five Icositetrahedrons, with twenty-four faces.
6. One Tetracontaoctahedron, with forty-eight faces.

The dodecahedrons are again distinguished according to the form of their faces into rhombic, trigonal, deltoid, and pentagonal dodecahedrons. One variety of icositetrahedron is named a tetrakishexahedron (*i. e.* four times six faces), being bounded by twenty-four isosceles triangles, arranged in six groups of four each. Another variety, also bounded by isosceles triangles, but arranged in three groups of eight, is named the triakisoctahedron (*i. e.* 3×8 faces). A third variety is the hexakistetrahedron (6×4 faces), bounded by scalene triangles, in four groups of six each. The fourth is the diakisdodecahedron (2×12 faces), bounded by equilateral trapeziums; whilst the fifth and most common variety, bounded by deltoid faces, not arranged into groups, retains the original name. Some of the crystals with forty-eight faces have these arranged in eight groups of six, and for such forms the term hexakisoctahedron (6×8 faces), seems preferable. Many mineralogists have named these forms from some particular mineral species in which they occur (thus the rhombic dodecahedron is the granatoid of Haidinger, the granatohedron of Weiss); but the above names are both more expressive and more easily remembered.

Before giving a particular description of these forms, we must remark that crystals are characterised not only by the number, but in a still higher degree by the relative position of their faces. When attentively compared in this respect, it will be observed that the faces of the tetrahedron exactly correspond in relative position to the alternate faces of the octahedron, so that if these latter faces were supposed to increase symmetrically so as to obliterate the others, the octahedron would be changed into a tetrahedron, or form with one-half the number of faces. This is also true of many other forms, the alternate faces of which increasing symmetrically obliterate the others, and thus produce new forms with only half the number of faces. Hence the distinction of crystals into holohedric or plenotesseral forms, in which the whole or full number of faces are developed; and hemihedric or semitesseral forms, in which only half the number of faces appear. The latter are again distinguished into two classes, the one with faces parallel to each other, two and two; the second with faces not parallel or inclined to each other. These must not be regarded as mere arbitrary distinctions of small importance, for they express laws which nature seems to observe in the formation of mineral bodies. In combinations of various forms, those with inclined and those with parallel faces are never found in union. It is even affirmed with much probability that no mineral species ever crystallizes in two of these classes of forms, and that the

apparent exceptions arise from certain forms, as the cube and octahedron, being both holohedric and hemihedric. A similar distinction of hemihedric and holohedric obtains in the other systems of crystallization, and in these also the several classes are no less strictly disjoined.

The following is a description, with figures, of the different forms above-mentioned, beginning with

The *Holohedric forms.*

1. The hexahedron or cube (fig. 1) is bounded by six equal squares, has twelve edges, formed by faces meeting at 90°, and eight trigonal angles. The principal axes join the centre points of any two opposite faces.—Examples are fluor spar, lead-glance, boracite.

Fig. 1.

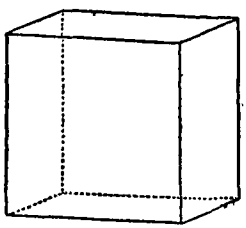
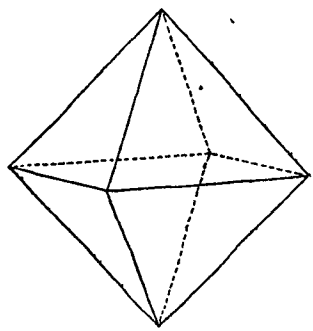


Fig. 2.



2. The octahedron, (fig. 2), bounded by eight equilateral triangles, has twelve equal edges, with planes meeting at 109° 28′, and six tetragonal angles. The principal axes join the opposite angles, two and two.—Ex. alum, spinel, magnetic iron ore.

3. The rhombic-dodecahedron (fig. 3) is bounded by twelve equal

Fig. 3.

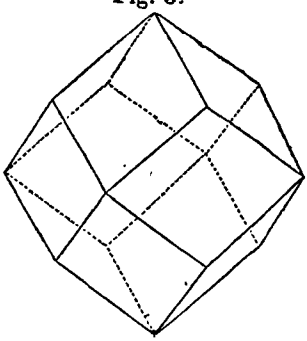
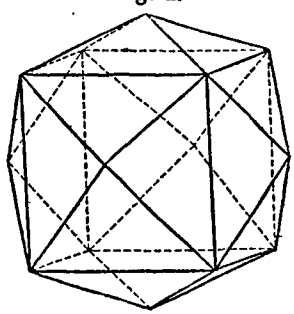


Fig. 4.



and similar rhombs, (diagonals as 1 and $\sqrt{2}$), has twenty-four equal

edges of 120°, and six tetragonal and eight trigonal angles. The principal axes join two opposite tetragonal angles.—Ex. garnet, red copper ore, boracite.

4. The tetrakishexahedrons (fig. 4) are bounded by twenty-four isosceles triangles. They have twelve longer edges which correspond to those of the primitive or inscribed cube, and twenty-four shorter edges placed over each of its faces. The angles are eight hexagonal and six tetragonal, the latter joined two and two, by the three principal axes. This form varies in general aspect, approaching on the one hand to the cube, on the other to the rhombic-dodecahedron, according as the vertical angles of the bounding triangles become more or less obtuse, or, in other words, approach or recede from the face of the inscribed cube.—Ex. fluor spar, gold.

5. The triakisoctahedrons (fig. 5) are bounded by twenty-four isosceles triangles, and like the previous form vary in general aspect from the octahedron on one side, to the rhombic-dodecahedron on the other. The edges are twelve longer, corresponding with those of the inscribed octahedron, and twenty-four shorter, three and three over each of the faces. The angles are eight trigonal and six ditetragonal, (formed by eight faces); the latter angles joined two and two by the principal axes.—Ex. galena, diamond.

Fig. 5.

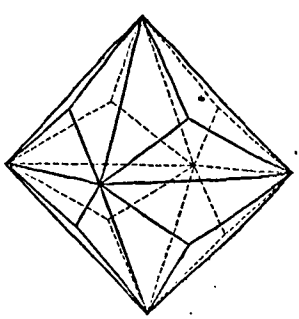
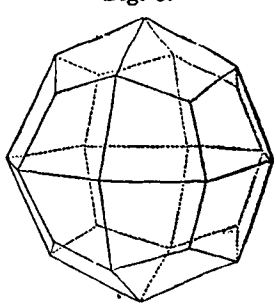


Fig. 6.

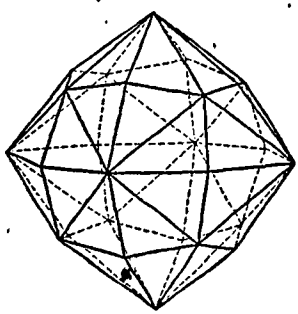


6. The icositetrahedrons (fig. 6) are bounded by twenty-four deltoids or figures with four sides, of which two and two adjacent ones are equal. This form varies in the limits from the octahedron to the cube, sometimes approaching the former, sometimes the latter in general aspect. The edges are twenty-four longer, and twenty-four shorter. The angles are six tetragonal joined by the principal axes, eight trigonal, and twelve rhombic, or tetragonal with unequal angles.

7. The hexakisoctahedrons (fig. 7), bounded by forty-eight scalene triangles, vary much in general aspect, approaching more or less to all

the preceding forms; but most frequently they have the faces arranged either in six groups of eight, or eight of six, or twelve of four faces. There are twenty-four long edges, often corresponding to those of the rhombic-dodecahedron; twenty-four intermediate edges lying in pairs over each edge of the inscribed octahedron; and twenty-four short edges in pairs over the edges of the inscribed cube. There are six ditetragonal angles joined by the principal axes, eight hexagonal and twelve rhombic angles. — Ex. fluor spar, garnet, diamond.

Fig. 7.



The seven forms of crystals now described are related to each other in the most intimate and interesting manner. Even on a cursory view it is evident that they all have a general similarity, so that one as it were passes into or separates from the others almost by insensible gradations. This will appear more distinctly from the following account of the derivation of the forms, with which is conjoined an explanation of the crystallographic signs or symbols by which they are designated in the system of Naumann. We have adopted these symbols throughout the work, in the belief that they not only mark the forms in a greatly-abbreviated manner, enabling us to dispense with many long and cumbrous words, but also exhibit the relations of the forms and combinations in a way which words could hardly accomplish, and thus impart much valuable information which could not otherwise be obtained.

By the *derivation of forms* is understood that process by which, from one form chosen for the purpose, and considered as the *type*, the *fundamental* or *primary form*, all the other forms of that system may be produced, according to certain fixed principles or general laws. In order to understand this process or method of derivation, the student should keep in mind that the position in space of any plane is fixed when the positions of any three points in it, not all in one straight line, are known. To determine the position, therefore, of the face of a crystal, it is only necessary to know the distance of three points in it from the centre of the crystal, or the points in which the face or its supposed extension would intersect the three axes of the crystal. The portion of the axes between the face of the crystal and the centre are named the parameters of the face, and the position of the latter is considered as sufficiently known when the relative length or proportion of these parameters is known, though it may not be expressed in lines, inches, or

other measure. It should also be remembered that when the position of one face is thus fixed or described, all the other faces are in like manner fixed, since they are all equal and similar, and all intersect the axes in a uniform manner. The expression, therefore, which marks or describes one face of a simple form of a crystal, marks and describes the whole figure.

Some authors have assumed the cube, or hexahedron, as the fundamental or primary form of the tesseral system from which the others may be derived, but the octahedron possesses so many advantages for this purpose, that it is generally adopted, and is taken as the primary or fundamental form, and distinguished by the first letter of the name, O. Its faces cut the half axes at equal distances from the centre; so that these semiaxes, or the parameters of the faces, have to each other the proportion 1 : 1 : 1. In order to derive the other forms from the octahedron, the following construction is employed. The numbers refer to the descriptions above.

Suppose a plane so placed in each angle of the octahedron as to be vertical to the axis passing through that angle, and consequently to be parallel to the two other axes, (or to cut them at an infinite distance $= \infty$); then the hexahedron or cube (1) is produced, designated by the crystallographic sign $\infty O \infty$; expressing the proportion of the parameters of its faces, or $\infty : \infty : 1$. Figure 8, a combination of the

Fig. 8.

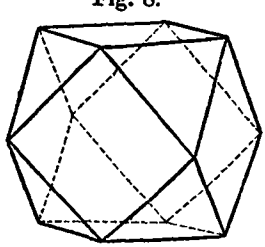
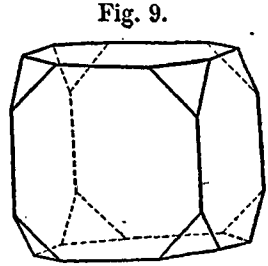


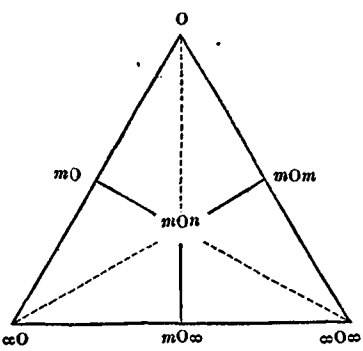
Fig. 9.



two forms, shows this process partly begun, whilst in figure 9 the secondary planes of the cube have almost obliterated the primary ones of the octahedron. If a plane is supposed placed in each edge parallel to one axis, and cutting the two other axes at equal distances, the resulting figure is the rhombic-dodecahedron (3), designated by the sign ∞O, the proportion of the parameters of its faces being $\infty : 1 : 1$. The triakisoctahedron (5) arises when on each edge of the octahedron planes are placed, cutting the axis not belonging to that edge at a distance from the centre m, which is a rational number greater than 1. The proportion of its parameters is, therefore, $m : 1 : 1$, and its sign mO; the most common varieties being $\frac{3}{2}O$, $2O$, and $3O$. When, on

the other hand, from a similar distance m in each two semiaxes prolonged, a plane is drawn to the other semiaxis, or to each angle, an ikositetrahedron (6) is formed; the parameters of its faces have consequently the proportion $m:1:m$, and its sign is mOm; the most common varieties being 202 and 303, the former very frequent in leucite, analcime, and garnet. When again planes are drawn from each angle, or the end of one semiaxis of the octahedron, parallel to a second axis, and cutting the third at a distance n, greater than 1, then the tetrakishexahedron (4) is formed, the parameter of its faces $\infty:1:n$; its sign ∞On; and the most common varieties in nature $\infty O\frac{3}{2}$, $\infty O2$, and $\infty O3$. Finally, if in each semiaxis of the octahedron two distances, m and n, be taken, each greater than 1, and m also greater than n, and planes be drawn from each angle to these points, so that the two planes lying over each edge cut the second semiaxis belonging to that edge, at the smaller distance n, and the third axis at the greater distance m, then the hexakisoctahedron (7) is produced, the parameters of which are as $m:n:1$, its sign mOn, and the most common varieties $3O\frac{3}{2}$, $4O2$, and $5O\frac{5}{2}$.

Fig. 10.



The mutual relation of these forms to each other, and their mode of derivation, is represented in the prefixed figure (fig. 10). At the vertex of the triangle is the octahedron as the primary or fundamental form. By a change in one axis only, the forms on the left hand side of the figure are produced, m having all dimensions between 1 and ∞, and the forms mO consequently approaching either to O as it diminishes, or to ∞O as it increases. On the right hand side of the figure are the forms in which two of the axes vary uniformly, whilst one remains unchanged, m again having all magnitudes from 1 to ∞. In the centre line are the forms in which two axes vary, but not uniformly, so that in them the parameters of the faces are all of different dimensions. The forms on the sides are, therefore, the three variable forms whose extreme limits are marked by those at the respective angles, which are fixed forms presenting only one variety. In the centre again is the hexakisoctahedron, uniting the signs and proportions of all the other forms, and hence their common representative. In it the whole number of faces be-

longing to this system are separately shown, whereas in the other forms two or more of these faces usually coincide, so that the number appears smaller.

The next class of crystals are the semitesseral forms, and first those with oblique faces, often named tetrahedral, from their relation to the tetrahedron. (1.) This form (fig. 11) is bounded by four equilateral triangles, has six equal edges with faces meeting at 70° 32′, and four trigonal angles. The principal axes join the middle points of each two

Fig. 11.

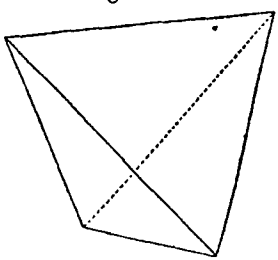
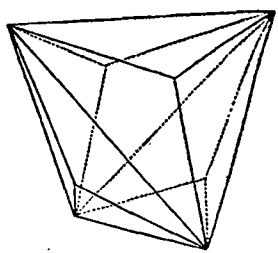


Fig. 12.



opposite edges.—Ex. are grey-copper ore, boracite, and helvine. (2.) The trigonal dodecahedrons (fig. 12) are bounded by twelve isosceles triangles, and vary in general form from the tetrahedron to the hexahedron. There are six longer edges, corresponding to those of the inscribed tetrahedron, and twelve shorter placed three and three over each of its faces; and four hexagonal and four trigonal angles.—Ex. grey-copper ore, and bismuth-blende. (3.) The deltoid-dodecahedrons (fig. 13) are bounded by twelve deltoids, and vary in general form from the tetrahedron on the one hand, to the rhombic-dodecahedron on the other. They have twelve longer edges lying in pairs over the edges of the inscribed tetrahedron; and twelve shorter edges, three and three over

Fig. 13.

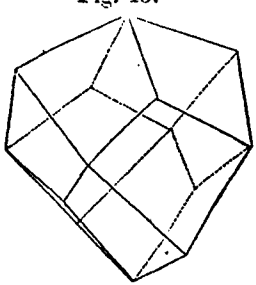
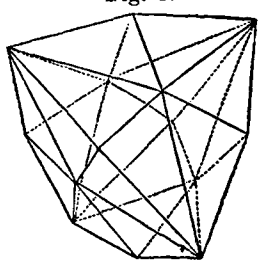


Fig. 14.



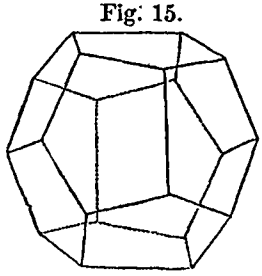
each of its faces. The angles are six tetragonal (rhombic), four acute trigonal and four obtuse trigonal angles. The principal axes join two

and two opposite rhombic angles.—Ex. grey-copper ore. (4.) The hexakistetrahedrons (fig. 14) are bounded by twenty-four scalene triangles, and approach in general form sometimes to one of the three previous forms, sometimes to the rhombic-dodecahedron, or the hexahedron, or the tetrakishexahedron; but most commonly have their faces grouped in four systems of six each. The edges are twelve shorter and twelve longer, lying in groups of three over each face of the inscribed tetrahedron, and twelve intermediate in pairs over its edges. The angles are six rhombic, joined in pairs by the principal axes, and four acuter and four obtuser hexagonal angles.—Ex. diamond.

The derivation and signs of these forms are as follows. The tetrahedron arises when four alternate faces of the octahedron are enlarged, so as to obliterate the other four, and its sign is hence $\frac{O}{2}$. But, as either four faces may be thus enlarged or obliterated, two tetrahedrons can be formed, similar in all respects except in position, and together making up the octahedron. These are distinguished by the signs + and —, added to the above symbol, but only the latter in general expressed thus— $\frac{O}{2}$. In all hemihedric systems two forms similarly related occur, which may thus be named complementary forms. The trigonal dodecahedron is derived from the icositetrahedron by the expansion of the alternate trigonal groups of faces. Its sign is $\frac{mOm}{2}$, the most common variety being $\frac{2O2}{2}$ found in grey-copper ore. The deltoid-dodecahedron is in like manner the result of the increase of the alternate trigonal groups of faces of the triakisoctahedron, and its sign is $\frac{mO}{2}$. Lastly, the hexakistetrahedron arises in the development of alternate hexagonal groups of faces in the hexakisoctahedron, and its sign is $\frac{mOn}{2}$.

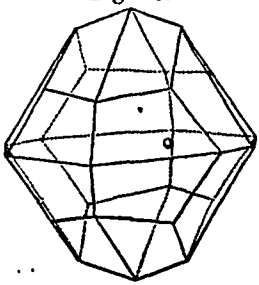
The parallel-faced semitesseral forms are two. (1). The pentagonal dodecahedrons (fig. 15) are bounded by twelve symmetrical pentagons, and vary in general aspect between the hexahedron and rhombic-dodecahedron. They have six regular (and in general longer) edges, lying over the faces of the inscribed hexahedron, and twenty-four generally shorter (seldom longer) edges, usually lying in pairs over its edges. The angles are eight of three equal angles, and twelve of three unequal angles. The principal axes unite each two opposite regular edges. This form is derived from the tetrakishexahedron, and its sign is $\frac{\infty On}{2}$, one of the most common varieties being $\frac{\infty O2}{2}$ found frequently

Fig. 15.



in iron pyrites and cobaltine. (2.) The dyakisdodecahedron (fig. 16),

Fig. 16.



bounded by twenty-four trapezoids with two sides equal, has twelve short, twelve long, and twenty-four intermediate edges. The angles are six equiangular rhombic, united in pairs by the principal axes, eight trigonal, and twenty-four irregular tetragonal angles. It is derived from the hexakisoctahedron, and its sign is $\left[\frac{mOn}{2},\right]$ the brackets being used to distinguish it from the hexakistetrahedron, also derived from the same primary form. It occurs in iron pyrites and cobaltine. There are two other tetrahedral forms, the pentagonal dodecahedron (fig. 17), and the

Fig. 17.

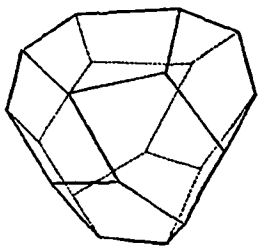
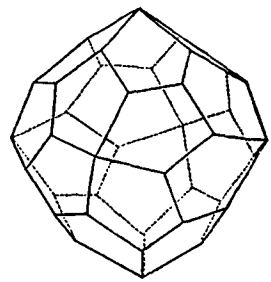


Fig. 18.



pentagonal icositetrahedron, (fig. 18), both bounded by irregular pentagons, but not yet observed in nature.

Combinations.—These forms of the tesseral system (and this is true also of the five other systems of crystallization), not only occur singly, but often two or three united in the same crystal, forming what are named combinations. In this case it is evident that no one of the individual forms can be completely developed, because the contemporaneous existence of several on one crystal, or round one common centre, is only possible on the condition that the faces of one form shall partially interfere with the faces of another. A combination, therefore, implies that the faces of one form shall appear symmetrically disposed between the faces of the other forms, and consequently in the room of certain of their edges and angles. These edges and angles are thus as it were cut off, and new ones formed in their place, which properly belong neither to the one form nor the other, but are edges or angles of combination. Usually,

one form predominates more than the others, or has more influence on the general aspect of the crystal, and hence is distinguished as the predominant form, the others being named subordinate. Here again the universality of the general law will be remarked, that only forms of the same system and of the same division of it can combine together. The following terms used on this subject require explanation. A combination is *developed* when all the forms contributing to its formation are pointed out; and its sign consists of the signs of these forms, written in the order of their influence on the combination with a point between. An angle or edge is said to be *replaced*, when it is cut off by one or more secondary planes; it is *truncated* when cut by one plane, forming equal angles with the adjacent faces; and an edge is *beveled* when replaced by two planes, which are equally inclined to the adjacent faces.

It will be readily seen that such combinations may be exceedingly numerous, or rather infinite; and only a few of the most common can be noticed, simply as specimens of the class. Many others more complicated will occur in the descriptive part of this treatise. Among plenotesseral combinations, the cube, octahedron, and also the rhombic dodecahedron, are the predominant forms. In fig. 19 the cube

Fig. 19.

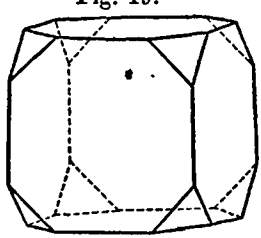
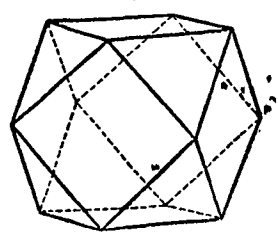


Fig. 20.



has its angles replaced by the faces of the octahedron, and the sign of this combination is $\infty O \infty . O$. In fig. 20 this process may be re-

Fig. 21.

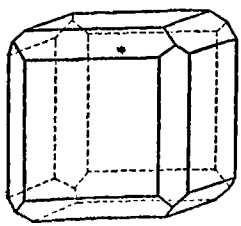
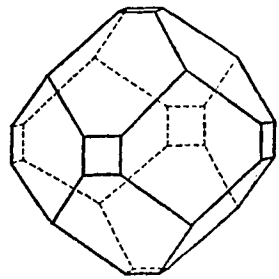


Fig. 22.



garded as having proceeded still further, so that the faces of the octahedron now predominate, and the sign, of the same two elements but in reverse order, is $O.\infty O\infty$. In fig. 21, the cube has its edges replaced by the faces of the rhombic-dodecahedron, the sign being $\infty O\infty . \infty O$; whilst in fig. 22 there is the same combination, but with the faces of the cube subordinate, and hence the symbol is $\infty O . \infty O\infty$. The former figure, it will be seen, has more the general aspect of the cube, the latter of the dodecahedron.

In combinations of semitesseral forms with oblique faces, the tetrahedron, the rhombic-dodecahedron, or even the hexahedron, seldomer a trigonal-dodecahedron, are the more common predominant forms. In fig. 23, two tetrahedrons in opposite positions, $\frac{2}{2}$. — $\frac{2}{2}$, are com-

Fig. 23

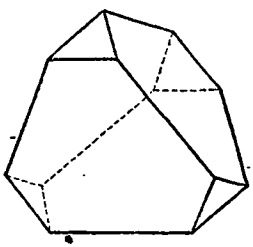
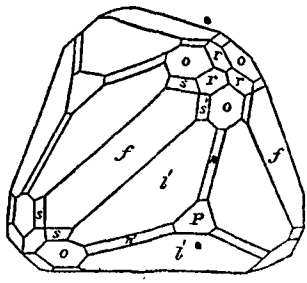


Fig. 24.



bined. In fig. 24 a very complex combination of seven forms is represented in a crystal of grey copper ore, its full sign being

$$\frac{2O2}{2}(l).\ \infty O\,\infty(f).\ \ \infty O(o).\ \ \frac{O}{2}(P).\ -\frac{2O2}{2}(r).\ \ \frac{\frac{3}{2}O}{2}(n).\ \ \infty O3(s).$$

the letters in brackets connecting them with the respective faces of the figure. As examples of combinations of semitesseral forms with parallel faces, we may take fig. 25, in which each of the angles of the

Fig. 25.

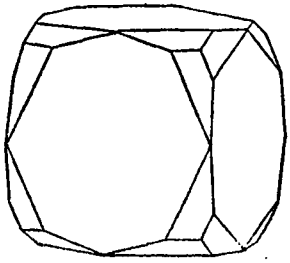
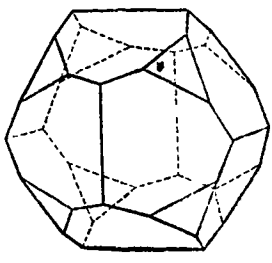


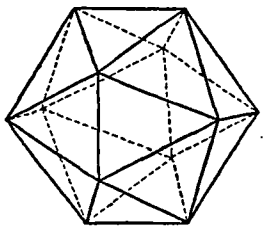
Fig. 26.



cube is unsymmetrically replaced by three faces of the dyakis-dodecahedron, and hence $\infty O\infty . \left[\frac{4O2}{2}\right]$; or fig. 26, in which the pentagonal

dodecahedron has its trigonal angles replaced by the faces of the octahedron, consequently with the sign $\frac{\infty 02}{2}$. O.—Figure 27 represents the same combination, but with greater predominance of the faces of the octahedron, the crystal being bounded by eight equilateral and twelve isosceles triangles. As formerly stated, the holohedral forms in these combinations are regarded by some authors as essentially hemihedral.

Fig. 27.



Tetragonal System.—This system agrees with the former in having three axes placed at right angles; but differs in that two of them are equal and one unequal. The last is considered the principal axis, having most influence on the symmetry of the forms, and when it is brought into a vertical position the crystal is said to be placed upright. Its ends are named poles, and the edges connected with them polar edges. The two other axes are named subordinate or lateral axes, and a plane passing through them is named the basis of the crystal. The two planes that pass through the principal and one of the lateral axes are named normal chief sections, and a plane through the chief axis intermediate to them a diagonal chief section. The name tetragonal is derived from the form of the basis, which is usually quadratic.

There are eight tetragonal forms, of which five are *closed*,—that is, bounded on all sides by planes, and of definite extent; and three *open*, which in certain directions are not bounded, and consequently of indefinite extent. The latter, as will subsequently appear, are only the limit-forms into which some of the former pass when the axes are infinitely extended.

Fig. 28.

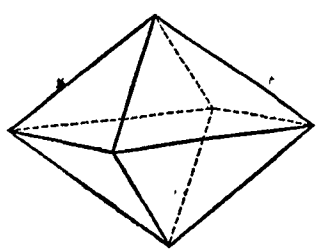
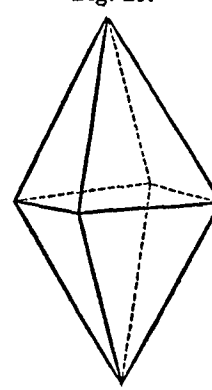


Fig. 29.



The description of the varieties is as follows, it being premised that a crystallographic pyramid is equivalent to two geometrical pyramids joined base to base. (1.) Tetragonal pyramids (figs. 28, 29) are enclosed by eight isosceles triangles, with four middle edges all in one plane, and eight polar edges. There are three kinds of this form arising in the different position of the lateral axes. In the first these axes unite the opposite angles; in the second they intersect the middle edges equally; and in the third they lie in an intermediate position, or divide these edges unequally; the latter being hemihedral forms. These pyramids are also distinguished as obtuse (fig. 28) or acute (fig. 29), according as the vertical angle is greater or less than in the octahedron, which, though thus intermediate between these, is never considered a tetragonal form. (2.) Ditetragonal pyramids (fig. 30) are

Fig. 30.

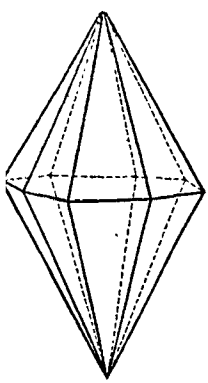
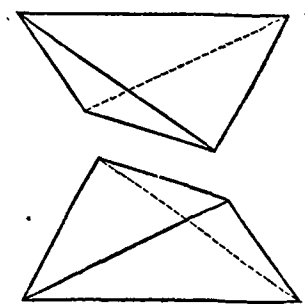


Fig. 31.



bounded by sixteen scalene triangles, whose base lines are all in one plane. Their polar edges are named normal when they lie in the normal chief section, or diagonal when in an intermediate position. This form rarely occurs except in combinations. (3.) The tetragonal sphenoids (fig. 31) are bounded by four isosceles triangles, and are the hemihedral forms of the first variety of tetragonal pyramids, from which they arise in the same manner as the tetrahedron from the octahedron. (4.) The tetragonal scalenohedron (fig. 32), bounded by eight scalene triangles, whose bases rise and fall in a zig-zag line, is the hemihedral form of the ditetragonal pyramid. The latter two forms are rare; and the fifth tetragonal form, the trapezohedron only, if ever, observed in scapolite, needs no further notice.—The tetragonal prisms (fig. 33) are bounded by four planes parallel to the principal axis; the ditetragonal by eight similar planes. In them the principal axis is supposed to be prolonged infinitely or to be un-

bounded. Where it is very short and the lateral axes infinite, the basal pinacoid is formed, consisting merely of two parallel faces.

Fig. 32.

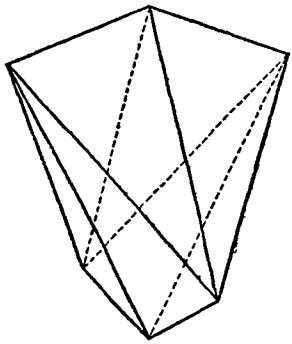
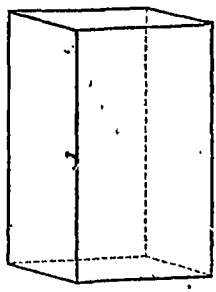


Fig. 33.



Both it and the prisms are open, and consequently must be bounded by some other forms.

The various series of tetragonal crystals found in the different species of the mineral kingdom are distinguished from each other only by their relative dimensions. To determine these, one of the series must be chosen as the fundamental form, and for this purpose a tetragonal pyramid of the first variety, designated by P as its sign, is selected. The angle of one of its edges, especially the middle edge, found by measurement, determines its angular dimensions; whilst the proportion of the principal axis (a) to the lateral axes supposed equal to 1, gives its linear dimensions. The parameters, therefore, of each face of the fundamental form are $1 : 1 : a$.

Now if m be any (rational) number, either less or greater than one, and if from any distance ma in the principal axis planes be drawn to the middle edge of P, then new tetragonal pyramids of the first kind, but more or less acute or obtuse than P, are formed. The general sign of these pyramids is mP, and the most common varieties $\frac{1}{2}$P, 2P, 3P; with the chief axis equal to $\frac{1}{2}$, twice or thrice that of P. If m becomes infinite, or $= \infty$, then the pyramid passes into a prism, indefinitely extended along the principal axis, and with the sign ∞P; if $m = 0$, which is the case when the lateral axes are supposed infinite, then it becomes a pinacoid, consisting properly of two basal faces, open towards the lateral axes and designated by the sign 0P. The ditetragonal pyramids are produced by taking in each lateral axis distances n greater than 1, and drawing two planes to these points from each of the intermediate polar edges. The parameters of these planes are, therefore, $m : 1 : n$, and the general sign of the form mPn,

the most common values of n being $\frac{1}{3}$, 2, 3, and ∞. When $n = \infty$, a tetragonal pyramid of the second kind arises, designated generally by $m\mathrm{P}\infty$, the most common in the mineral kingdom being $\mathrm{P}\infty$ and $2\mathrm{P}\infty$. The relation of these to pyramids of the first kind is shown in fig. 34, where ABBBX is the first, and ACCCX the second kind of pyramid. In like manner from the prism $\infty\mathrm{P}$, the ditetragonal prisms $\infty\mathrm{P}n$ are derived, and finally when $n = \infty$, the tetragonal prism of the second kind, whose sign is $\infty\mathrm{P}\infty$.

Fig. 34.

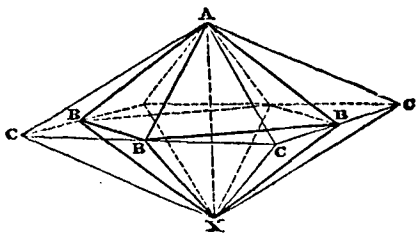
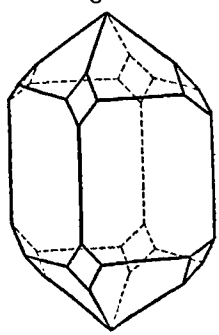


Fig. 35.



The combinations of the tetragonal system are either holohedric or hemihedric, but the latter are rare. Prisms and pinacoids must always be terminated on the open sides by other forms. Thus in figure 35 a square prism of the first kind is terminated by the primary pyramid, and has its lateral angles again replaced by another more acute pyramid of the second kind, so that its sign is $\infty\mathrm{P}$. P. $2\mathrm{P}\infty$. In figure 36 a prism of the second kind is first bounded by the fundamental

Fig. 36.

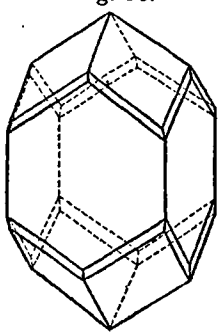
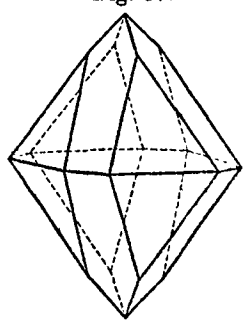


Fig. 37.



pyramid, and then has its edges of combination replaced by a ditetragonal pyramid, and its sign is here, $\infty\mathrm{P}\infty$. P. 3P3. In figure 37

the polar edges of the pyramid are replaced by another pyramid, its sign being P . P∞. In fig. 38 a hemihedric form very characteristic of copper pyrites is represented, P and P′ being the two sphenoids, *a*

Fig. 38.

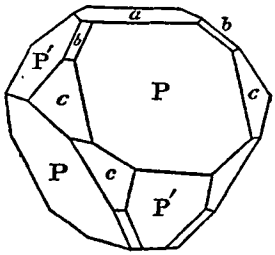
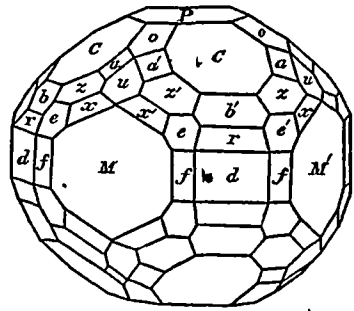


Fig. 39.



the basal pinacoid, and *b*, *c* two ditetragonal pyramids. In fig. 39 a crystal of idocrase is represented, combining no less than thirteen forms. Its sign with the corresponding letters on the faces subjoined is,

∞P∞ . P. 0P. ∞P. P∞. 2P∞. 2P. 4P. 2P2. 4P4. ∞P2. 4P2. ¾P3.

M c P d o u b r z x f e a

The Hexagonal System.—The essential character of this system is, that it has four axes,—three equal lateral axes intersecting each other in one plane at 60°, and one principal axis at right angles to them. The extremities of the principal axis are named poles, and sections through it and one lateral axis, normal chief sections. The plane through the lateral axes is the basis, and from its hexagonal form gives the name to the system. As in the last system its forms are either closed or open; and are divided into holohedral, hemihedral, and tetartohedral,—the last forms with only a fourth part of their faces developed. The tetartohedral and many of the hemihedral forms are of rare occurrence, and only a few of the more common require to be here described.

The hexagonal pyramids (figs. 40, 41) are bounded by twelve isosceles triangles, and are of three kinds, according as the lateral axes fall in the angles, in the middle of the lateral edges, or in another point of these edges, the latter being hemihedral forms. They are also classed as acute or obtuse, but without any very precise limits. The trigonal pyramid,—shown by G. Rose to occur in quartz,—is bounded by six triangles, and may be viewed as the hemihedral form of the hexagonal. The dihexagonal pyramid is bounded by twenty-four scalene triangles, but has never been observed alone, and rarely even in combinations. These forms when the principal axis becomes infinite pass into prisms, the first producing the hexagonal prism of six sides, the latter the

dihexagonal of twelve sides; or form similar pinacoids when their chief axis equal to 0, or the lateral axes infinitely extended.

Fig. 40.

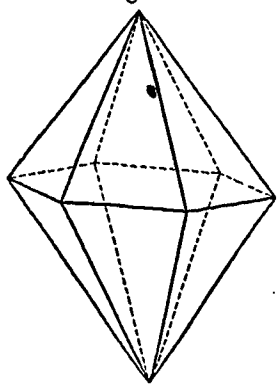
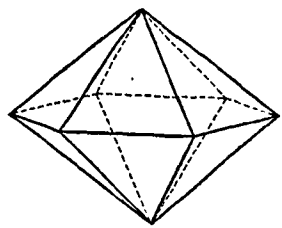


Fig. 41.



As the fundamental form of this system, a particular pyramid P is chosen, and its dimensions determined either from the proportion of the lateral to the principal axis ($1 : a$), or from the measurement of its angles. From this form, (mP), others are derived exactly as in the tetragonal system. Thus dihexagonal pyramids are produced with the general sign, mPn, the chief peculiarity being that, whereas in the tetragonal system n might have any rational value from 1 to ∞, in the hexagonal system it can only vary from 1 to 2, in consequence of the geometric character of the figure. When $n = 2$ the dihexagonal changes into an hexagonal pyramid of the second kind, whose sign is mP2. When m is $= \infty$ various prisms arise from similar changes in the value of n.

Few hexagonal mineral-species form perfect holohedric combinations. Though quartz and apatite usually appear as such, yet properly the former is a tetartohedral ρ the latter a hemihedral species. In holohedric species the predominant faces are usually those of the two hexagonal prisms, ∞P, and ∞P2, or of the pinacoid, 0P; whilst the pyramids P and 2P2 are the most common subordinate faces. Figure 42 represents the prism, bounded on the extremities by two pyramids; one, P forming the point, the other 2P2 the rhombic faces on the angles, or ∞P. P. 2P2. Sometimes the prism and first pyramid are combined with the pinacoid, the latter cutting off the point of the crystal. At other times the lateral edges of the prism are replaced by the second prism ∞P2, producing an equiangular twelve-sided prism, which always represents the combination ∞P. ∞P2, and cannot occur as a simple form. An example of a more complicated combination is seen in this fig. 43, of a crystal of apatite, whose sign with

the corresponding letters is, ∞P (*M*). ∞P2 (*e*). 0P (*P*). ½P (*r*). P (*x*). 2P (*z*). P2 (*a*). 2P2 (*s*). 4P2 (*d*).

Fig. 42.

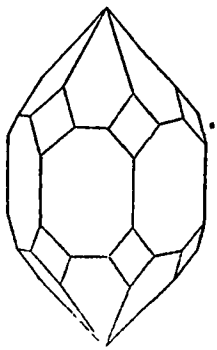
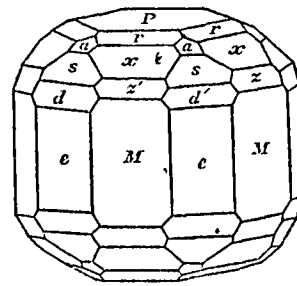
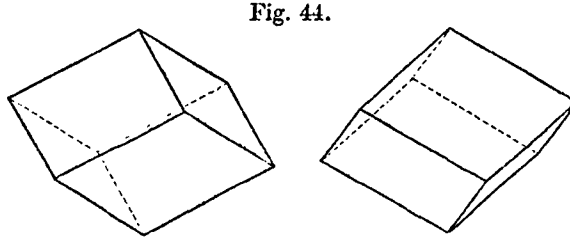


Fig. 43.



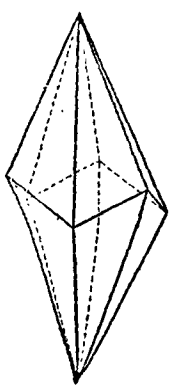
Hexagonal minerals more frequently crystallize in those series of hemihedral forms that are named rhombohedral, from the pre-

Fig. 44.



valence in them of rhombohedrons. These are (fig. 44) bounded by six rhombs, whose lateral edges do *not* lie in one plane but rise and fall in a zig-zag manner. The principal axis unites the two trigonal angles, formed by three equal plane angles, and in the most common variety the secondary axes join the middle points of two opposite sides. When the polar edges form an angle of more than 90° the rhombohedrons are named obtuse, when of less acute.

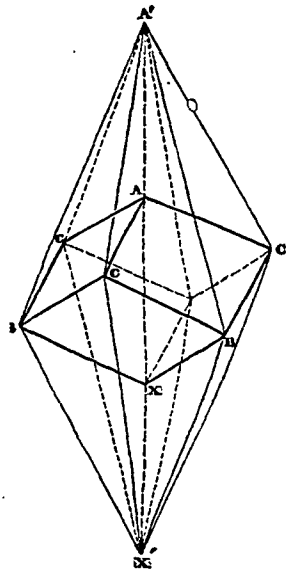
Fig. 45.



Hexagonal scalenohedrons (fig. 45) are bounded by twelve scalene triangles, whose lateral edges do not lie in one plane. The principal axis joins the two hexagonal angles, and the secondary axes the middle points of two opposite lateral edges. It is a very remarkable peculiarity of the scalenohedron, that its lateral edges always correspond with those of a certain rhombohedron that may be

inscribed in it, and from which it may therefore be regarded as derived, a view illustrated by fig. 46.

Fig. 46.



The rhombohedron is derived from the first kind of hexagonal pyramid by the hemihedric development of its alternate faces. Its general sign should therefore be $\frac{mP}{2}$, but on several grounds it is found better to designate it by R or mR, and its complementary figure by $-m$R. When the prism or pinakoid arise as its limiting forms, they are designated by ∞R and 0R, though in no respect changed from the limiting forms ∞P and 0P of the pyramid. The scalenohedron is properly the hemihedric form of the dihexagonal pyramid, but is better derived from the inscribed rhombohedron mR. If the halves of the principal axis of this are multiplied by a definite number n, and then planes drawn from the extremities of this enlarged axis to the lateral edges of the rhombohedron, as in fig. 46, the scalenohedron is constructed. Hence it is designated by mR^n, the n being written on the right hand like an algebraic exponent: and the dihexagonal prism is in like manner designated by ∞R^n.

The combinations of rhombohedric forms are very numerous, some

Fig. 47.

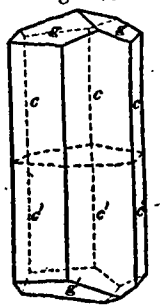
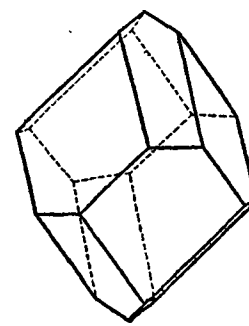


Fig. 48.



hundreds being described in calc-spar alone. Among the more com-

mon is the prism in combination with a rhombohedron, as in the twin crystal of calc-spar (fig. 47), with the sign ∞R. $-\frac{1}{2}R$, the lower half being the same form with the upper, but turned round 180°. In figure 48, the rhombohedron mR has its polar edges replaced by another rhombohedron $-\frac{1}{2}mR$; and in figure 49 its lateral edges bevelled by the scalenohedron mR^n. A more complex combination of five forms is

Fig. 49.

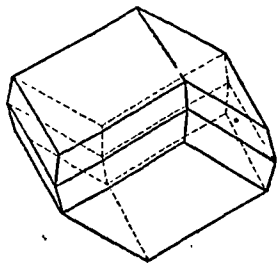
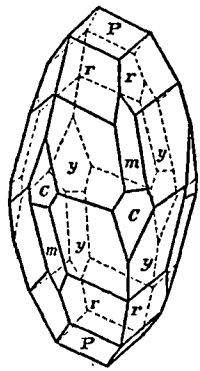


Fig. 50.



represented in the crystal of calc-spar, fig. 50, its sign with the letters on the faces being $R^5(y)$. $R^3(r)$. $R(P)$. $4R(m)$. $\infty R(c)$. Many other forms occur which will be exemplified in the descriptive part of the work; and we shall only allude further to the tetartohedric combinations of pure quartz or rock crystal, which shows this form of crystallization most distinctly, the pyramids of the first kind appearing as rhombohedrons, those of the second kind as trigonal pyramids, the dihexahedral prisms as ditrigonal prisms, and the prism $\infty P2$ as a trigonal prism. Most of these forms, however, occupy but a very subordinate place in the combinations which consist essentially of the prism ∞P, and the rhombohedron $R = {}_4$.

Rhombic System.—The Rhombic System is characterised by three axes, all unequal, but still at right angles to each other. One of these must be assumed as the chief axis, when the others are named subordinate, but mineralogists differ much in their choice of an axis for this purpose. The plane passing through the secondary axes or the basis forms a rhomb, and from this the name is derived. This system comprises only a few varieties of forms that are essentially distinct, and its relations are consequently very simple.

The closed forms are, (1st.) The rhombic pyramids (figs. 51, 52), bounded by eight scalene triangles, whose lateral edges lie in one plane,

Fig. 51.

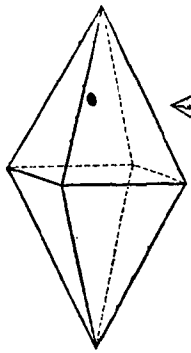
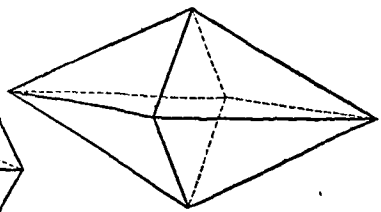
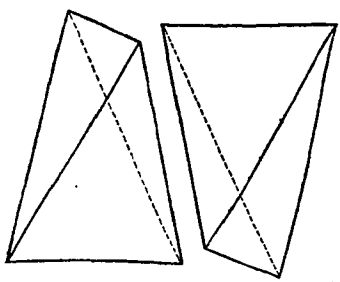


Fig. 52.



and form a rhomb. They have eight polar edges, four acute and four more obtuse, and four lateral edges, and six rhombic angles, the most acute at the extremities of the longest axis. (2d.) The rhombic sphenoids (fig. 53) are bounded by four scalene triangles with their lateral edges not in one plane; and are a hemihedric form of the rhombic pyramid of unfrequent occurrence. The open forms again are, (3d.) Rhombic prisms bounded by four planes parallel to one of the axes which is indefinitely extended. They are divided into upright and horizontal prisms, according as either the principal or one of the lateral axes is supposed to become infinite. For the latter form, the name doma or dome has been used; and two kinds, the macrodome and the brachydome, have been distinguished. Rhombic pinakoids also arise when one axis becomes = 0, and the two others are indefinitely extended.

Fig. 53.



In deriving these forms from a primary, a particular rhombic pyramid P is chosen, and its dimensions determined either from the angular measurement of two of its edges, or by the linear proportion of its axes $a : b : c$; the half of the greater lateral axis b being usually assumed equal to 1. To the greater lateral axis the name macrodiagonal is frequently given; to the shorter, that of brachydiagonal;

and the two principal sections are in like manner named macrodiagonal and brachydiagonal, according to the axis they intersect. The same terms are applied throughout all the derived forms, where they consequently mark only the position of the faces in respect to the axes of the fundamental crystal, without reference to the relative magnitude of the derived axes.

By multiplying the principal axis by any rational number m, greater or less than 1, a series of pyramids arise, whose general sign is mP, and their limits the prism and pinakoid, the whole series being contained in this formula, 0P - - - - - mP - - - - P - - - - mP - - - - ∞P; which is the fundamental series, the lateral axes always remaining unchanged. From each member a new series may, however, be developed in two directions by increasing one or other of the lateral axes. When the macrodiagonal is thus multiplied by any number n greater than 1, and planes drawn from the distance n to the polar edges, a new pyramid is produced, named a macropyramid, with the sign $m\bar{\mathrm{P}}n$, the mark over the P pointing out the axis enlarged. When $m = \infty$ a macrodome results, with the sign $m\bar{\mathrm{P}}\infty$. If the shorter axis is multiplied, then brachypyramids and brachydomes are produced with the signs $m\breve{\mathrm{P}}n$ and $m\breve{\mathrm{P}}\infty$. So also from the prism ∞P, on the one side, numerous macroprisms $\infty\bar{\mathrm{P}}n$, with the limiting macropinakoid $\infty\bar{\mathrm{P}}\infty$; on the other, numerous brachyprisms $\infty\breve{\mathrm{P}}n$, with the limit form $\infty\breve{\mathrm{P}}\infty$, or the brachypinakoid. In figs. 54, 55, the two domes are shown in their relation to the primitive pyramid, the signs on the faces being those used in the system of Mohs.

Fig. 54.

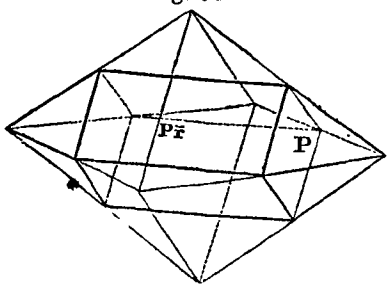
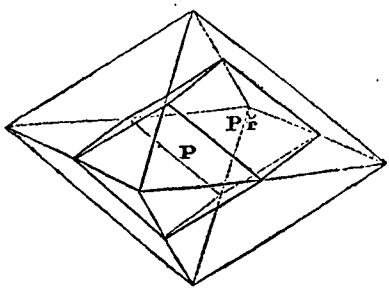


Fig. 55.



The pyramids seldom occur independent, or even as the predominant forms in a combination, sulphur, however, being an exception. Prisms or pinakoids usually give the general character to the crystal, which then appears either in a columnar or tabular, or even in a rectan-

gular pyramidal form. The determination of the position of these crystals, as vertical or horizontal, depends on the choice of the chief axis of the fundamental form. In the topaz crystal, fig. 56, the brachyprism and the pyramid are the predominant elements, associated with the prism, its sign and letters being $\infty\breve{P}2(l)$. $P(o)$, $\infty P(m)$. Fig. 57 of

Fig. 56.

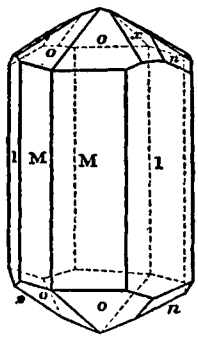


Fig. 57.

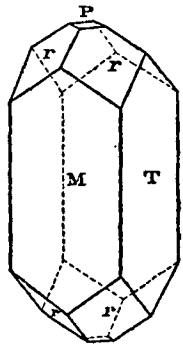
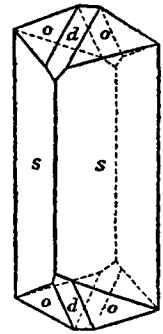


Fig. 58.



stilbite or desmine is another example, the macropinakoid $\infty\bar{P}\infty$ or M, being combined with the pyramid P (r), the brachypinakoid $\infty\breve{P}\infty$ (T) and the basal pinakoid $0P(P)$. Another instance is figure 58 of a lievrite crystal, where the brachyprism and pyramid combine with the macrodome, or $\infty\breve{P}2$. P . $\bar{P}\infty$. The following figures are very common forms of barytes; figs. 59 and 60 being both composed of

Fig. 59.

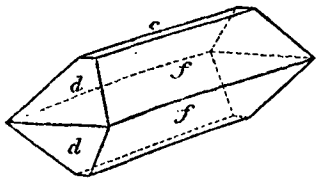


Fig. 60.

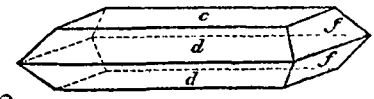
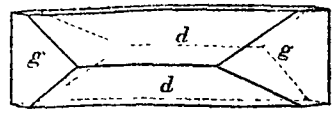


Fig. 61.



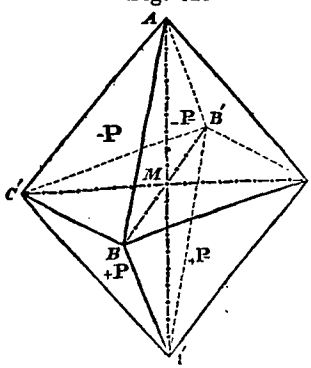
the pinakoid, a brachydome and macrodome with sign $0P(c)$. $\breve{P}\infty$ (f). $\frac{1}{4}\bar{P}\infty$ (d), the variation in aspect arising from the predominance of different faces; and fig. 61, consisting of the macrodome $\frac{1}{4}\bar{P}\infty$, the prism $\infty P(g)$, and the pinakoid 0P.

The Monoclinohedric System.—This system is characterised by three unequal axes, two of which intersect each other at an oblique angle, and are cut by the third at right angles. One of the oblique axes is chosen as the chief axis, and the other axes are then distinguished as the orthodiagonal (right-angled), and clinodiagonal (oblique-angled). The same terms are applied to the chief sections, and the name of the system refers to the fact that these two planes and the base, together with two right angles, form also an oblique angle *C*.

The forms of this system approach very near to those of the rhombic series, but the inclination of the axes, even when almost a right angle, gives them a peculiar character, by which they are always readily distinguished. Each pyramid thus separates into two altogether independent forms or hemipyramids. Three varieties of prism also occur—vertical, inclined, and horizontal—with faces parallel to the chief axis, the clinodiagonal, or the orthodiagonal. The horizontal prisms, like the pyramids, separate into two independent partial forms, named hemiprisms or hemidomes. The inclined prisms are often designated clinodomes, the term prism being restricted to the vertical forms. Orthopinakoids and clinopinakoids are also distinguished from their position in relation to the axes.

The monoclinohedric pyramids (fig. 62) are bounded by eight scalene triangles of two kinds, four and four only being similar. Their lateral edges lie all in one plane, and the similar triangles are placed in pairs on the clinodiagonal polar edges. The two pairs in the acute angle between the orthodiagonal and basal section are designated the positive hemipyramid; whilst the two pairs in the obtuse angles of the same sections form together the negative hemipyramid. But as these hemipyramids are wholly independent of each other, they are rarely observed combined in the complete form. More frequently each occurs alone, and then forms a prism-like figure, with faces parallel to the polar edges, and open at the extremities. Hence, like all prisms, they can only appear in combination with other forms. The vertical prisms are bounded by four equal faces parallel to the principal axis, and the cross section is a rhomb; the clinodomes have a similar form and section; whilst the horizontal prisms or domes have unequal faces, and their section is a rhomboid.

Fig. 62.



The mode of derivation of these forms closely resembles that of the

rhombic series. A complete pyramid is assumed as the fundamental form, and designated $\pm$ P, in order to express the two portions of which it consists. Its dimensions are given when the proportion of its axes $a : b : c$, and the angular inclination of the oblique axes C, which is also that of the orthodiagonal section to the basis, are known. The fundamental series of forms is, 0P - - - - $\pm$ mP - - - - $\pm$P - - - - $\pm m$P - - - - ∞P ; from each of whose members, by changing the dimensions of the other axes, new forms may be again derived. Thus from $\pm$ mP, by multiplying the orthodiagonal by any number n, a series of orthopyramids $\pm m$Pn, is produced with the orthodomes $\pm m$P∞, as limiting forms. The clinodiagonal produces a similar series, distinguished from the former by the sign being put in brackets, thus, $\pm$ (mPn,) with the limiting clinodome (mP∞) always completely formed, and therefore without the signs $\pm$ attached. From ∞P arise orthoprisms, ∞Pn, and the orthopinakoid, ∞P∞ ; and clinoprisms (∞Pn) and the clinopinakoid (∞P∞).

The combinations of this system may be easily understood from their resemblance to those of the rhombic ; the chief difficulty being in the occurrence of partial faces, which, however, closely resemble the hemihedric forms of the previous systems. We shall therefore only select a few examples frequently observed in the mineral kingdom. Fig. 63 represents a very common form of gypsum crystals (∞P∞) (P) . ∞P(f) . P (l). The most common form of augite is represented in fig. 64, with the sign ∞P (m) . ∞P∞ (r) . (∞P∞) (l) . P (s).

Fig. 63.

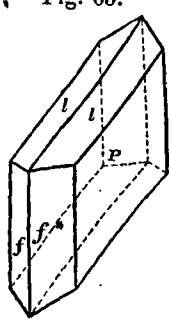


Fig. 64.

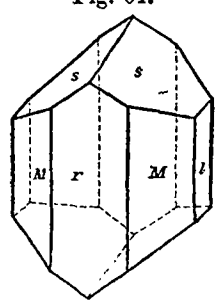


Figure 65 is a crystal of common felspar or orthoclase, composed of the clinopinakoid (∞P∞) (M), the prism, ∞P (T), the basal pinakoid 0P (P), and the hemidomes, 2P∞ (y) : to which, in fig. 66 of the same mineral, the hemipyramid, P (o), and the clinodome (2P∞) (n), are added.

Fig. 65.

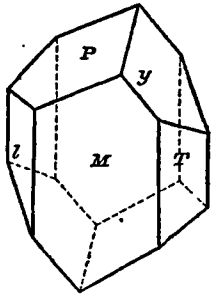
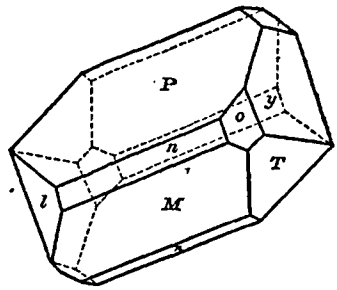


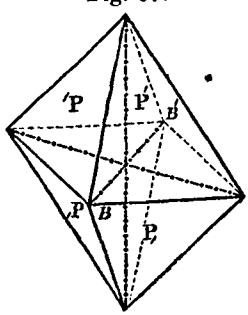
Fig. 66.



Triclinohedric System.—This is the least regular of all the systems, and departs the most widely from symmetry of form. The axes are all unequal and inclined at different angles, so that to determine any rystal or series of forms the proportion of the axes $a : b : c$, and also their angles, or those of the inclination of the chief sections, must be known. As in the previous system one axis is chosen as the principal axis, and the two others distinguished as the macrodiagonal and erachydiagonal axes. In consequence of the oblique position of the principal sections, this system consists entirely of partial forms wholly independent on each other, and each composed only of two parallel faces. The complete pyramid is thus broken up into four distinct quarter pyramids; and the prism into two hemiprisms. Each of these partial forms is thus nothing more than a pair of parallel planes, and the various forms consequently mere individual faces. This circumstance renders many series of triclinohedric crystals very unsymmetrical in appearance.

Triclinohedric pyramids (fig. 67) are bounded by eight triangles, whose lateral edges lie in one plane. They are equal and parallel two and two to each other; each pair forming, as just stated, a tetartopyramid or open form, only limited by combination with other forms, or, as we may suppose, by the chief sections. The prisms are again either vertical or inclined; the latter named domes, and their section is always rhomboidal. In deriving the forms, the fundamental pyramid is placed upright with its brachydiagonal axis to the spectator, and the partial forms designated, the two upper by 'P and P', the two lower by ,P and P,, as in the figure. The further derivation

Fig. 67.



now follows as in the rhombic system, with the modifications already mentioned, so that we need not delay on it longer, especially as the minerals crystallising in these forms are not numerous.

Some combinations of this system, as the series exhibited by most of the felspars, approach very near to the monoclinohedric system; whilst others, as the blue copper, or vitriol, and axinite, show great incompleteness and want of symmetry. In the latter case the determination of the forms is often difficult and requires great attention. As specimens, we may notice the albite crystal (fig. 68), in which *P* is the basal pinakoid 0P, *M* the brachydiagonal pinakoid $\infty\bar{P}\infty$, *s* the upper right pyramid P′, *l* the right hemiprism ∞P′, *T* the left hemiprism ∞'P, and *x* the hemidome $'\bar{P}'\infty$. Figures 69 and 70 are crystals of axinite, the former from Dauphiné, the latter very common in Cornwall, of whose faces the following is Naumann's development, *r* the macropinakoid $\infty\bar{P}\infty$; *l* the left hemiprism ∞'P; *u* the left upper quarter pyramid $'$P; *l* the left upper quarter pyramid 2′P; *s* the left upper partial form of the macropyramid $3'\bar{P}3$, and *x* the hemidome $2'P,\infty$.*

Fig. 68.

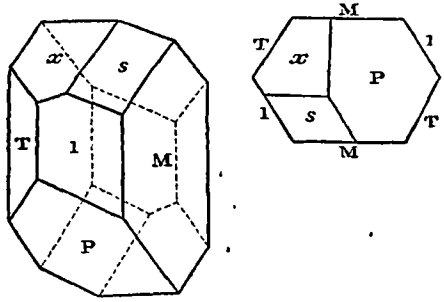


Fig. 69.

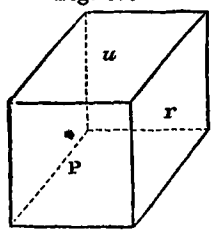
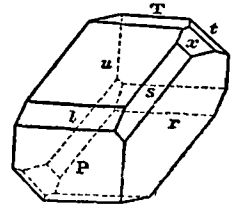


Fig. 70.



Imperfections of Crystals.

In the foregoing description of the forms of crystals, the planes have always been supposed smooth and even, the faces equal and uniform, or at the same distance from the centre or point of intersection of the axes, and each crystal also perfect or fully formed

* Some authors combine the 4th, 5th, and 6th systems in one, considering the latter two as mere subdivisions of the rhombic. In some respects this view is advantageous, but in others tends to render the subject more complex, and therefore is not adopted here.

and complete on every side. In nature, however, these conditions are rarely, if ever, realized, and the edges of crystals are seldom straight lines, or the faces mathematical plane surfaces. A very interesting variety of these irregularities which pervades all the systems, except the tesseral, is named *hemimorphism* by Breithaupt and others. In this the crystals are bounded on the opposite ends of their chief axis by faces belonging to wholly distinct forms, and hence only the upper or under half of each form is produced, or the crystal, as the name implies, is half-formed. Figure 71 represents a common variety of tourmaline, bounded on the upper end by the planes of the

Fig. 71.

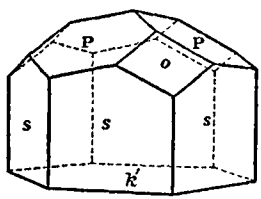
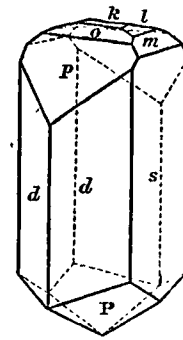


Fig. 72.



rhombohedrons R and —2R, and on the lower end by the basal pinakoid. In fig. 72 of electric calamine, the upper extremity shows the basis *k*, two brachydomes *o* and *p*; and two macrodomes *m* and *l*; whilst on the lower end it is bounded by the faces P of the primary form. This appearance becomes more interesting from the fact, that most hemimorphic crystals acquire polar-electricity from heat, that is, exhibit opposite kinds of electricity at opposite ends of the crystal.

The faces of crystals are very frequently rendered imperfect by *striæ* or minute linear and parallel elevations and depressions. These are believed to arise in the oscillatory combination of two crystalline forms, alternately prevailing through small spaces. The striæ, therefore, are in reality the edges of combined forms, and can often be readily interpreted on this theory. They are very common on quartz, shorl, and some other minerals; and frequently indicate combinations where only a simple form would otherwise appear to exist. The cubes and pentagonal dodecahedrons of iron pyrites are frequently striated, and in three directions at right angles to each other. In calcspar the faces of the rhombohedron, —½R (*g* in fig. 47 above) are almost never without striæ parallel to the oblique diagonal. The

striation is said to be simple, when only one series of parallel lines appears on each face; or feathered when two systems diverge from a common line. In other crystals the faces, then said to be *drusy*, are covered by numerous projecting angles of smaller crystals; an imperfection often seen in fluor spar. When these again become so small as to be no longer determinable, the surface is said to be rough; but a similar imperfection is also occasioned by other inequalities. The faces of crystals occasionally appear curved either as in tourmaline and beryl from the peculiar oscillatory combination mentioned; or by the union of several crystals at obtuse angles like stones in a vault, as in desmin and prehnite. A true curvature of the faces probably occurs in the saddle-shaped rhombohedrons of brown spar and iron spar (see Mohs, i. fig. 180), in the lens-like crystals of gypsum, and in the curved faces so common on diamond crystals. In chabasite similar curved faces occur, but concave. In galena and augite the crystals are often rounded on the corners as if by an incipient state of fusion. On other crystals the faces are rendered uneven from inequalities following no certain rule. These imperfections frequently furnish valuable assistance in developing very complex combinations, since it appears that all the faces of each individual form are distinguished by the same peculiarity of surface.

Irregularities in the forms of crystals are produced when the corresponding faces are placed at unequal distances from the centre, and consequently differ in form and size. Thus the cubes and octahedrons of iron pyrites, galena and fluor spar are often lengthened along one axis. Quartz is subject to many such irregularities which are seen in a very remarkable manner on the beautiful transparent and sharply angular crystals from Dauphiné, which thus appear altogether unsymmetric. In such irregular forms the axes do not exactly agree with the definition above. Instead of one line, they are then represented by an infinite number of lines, parallel to the ideal axis of the figure. The same irregularity carried to a greater extent frequently causes certain faces required for the symmetry of the form, altogether to disappear —an irregularity distinct both from the hemihedrism and hemimorphism already mentioned. Again some crystals do not fill the whole space marked out by their outline, holes and vacancies being left in the faces, occasionally to such extent that they seem little more than mere skeletons. This appearance is very common on crystals produced artificially, either from solutions, by fusion, or by sublimation, as in common salt, alum, bismuth, silver, &c. A perfect crystal can only be produced when during its formation it is completely isolated, so as to have full room to expand on every side. Hence the most perfect crystals have been originally imbedded singly in some uniform rock

mass, and freed from this either by the natural decomposition of the stone, or by art. Such crystals present the individual mineral species in its most complete isolation and most perfect state of formation. Next to them in perfection are forms that grow singly on the surface of some mass of similar or distinct composition; and when the point of adherence is small such crystals show the form almost perfect and complete. When, however, many crystals are aggregated together, the one interferes with the formation of the other and various irregularities result. An incompleteness of form, or at least a difficulty in determining it, arises from the minuteness of some crystals, or from their contracted dimensions in certain directions. Thus some appear mere tabular or lamellar planes, whilst others run out into acicular, needle-shaped, or capillary crystals, in which no complete form is perceptible.

One important element, however, remains unchanged amid all these modifications of the general form of the crystal, or of the condition and aspect of its individual faces. However much crystals may vary in these respects or in linear dimensions, their angular measurement remains constant. In some monoaxial crystals, indeed, Mitscherlich has shown that increase of temperature produces an unequal expansion in different directions, slightly changing the relative inclination of the faces, but so small as to be scarcely perceptible in common measurements, and hence producing no ambiguity. More important are the angular changes which in many species accompany slight changes in chemical composition, particularly in the relative proportions of certain isomorphous elements. But notwithstanding all these limitations the great truth of the permanence of the angular dimensions of crystals, announced by Romé de l'Isle, remains unaffected; only, as Mohs well states, it must not be interpreted with a rigid immutability, inconsistent with the whole analogy of other parts of nature. In interpreting the forms presented to us we must always endeavour to bring them under some simple geometric law, through which alone they can be understood; being at the same time careful not to push this endeavour too far, and to imagine a simplicity which more accurate observation would have shown did not exist.

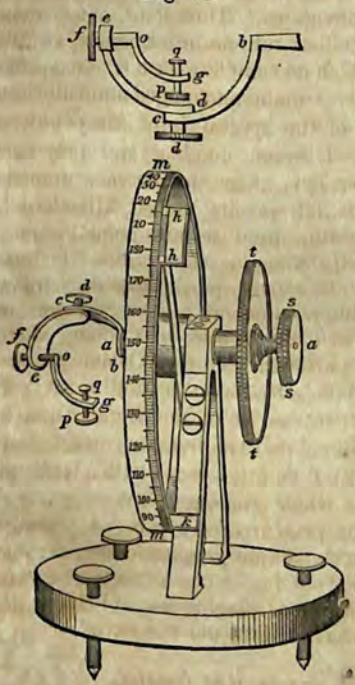
The Goniometer and Measurement of Crystals.

The fact just stated of the permanence of the angular dimensions of crystals, shows the importance of some accurate method of measuring their angles, that is, the inclination of two planes to each other. Two instruments have been specially used for this purpose,—the common or contact goniometer, invented by Caringeau, and the reflecting goniometer of Wollaston. The former is simply two brass rulers turning on a common centre, between which the crystal is so placed that its faces

coincide with the edges of the rulers, and the angle is then measured on a graduated arc. This instrument is sufficiently accurate for many purposes and for large crystals; but for precise determination is far inferior to the reflecting goniometer. This requires smooth and even faces, but these may be very small, even the hundredth of an inch, in skilful hands, and as small crystals are generally most perfect, far greater accuracy can be attained, and the measurements depended on to one minute (1′).

The reflecting goniometer is represented in the annexed figure. It

Fig. 73.



consists essentially of a graduated circle *m m*, divided on its edge into twice 180°, or more often into half degrees, the minutes being read of by the vernier *hh*. This circle turns on an axis connected with *tt*, so that by turning this the circle is moved round, but is stopped at 180°, when moving in one direction, by a spring at *k*. The other part of the instrument is intended to attach and adjust the crystal to be measured. The first axis of *mm* is hollow, and a second axis, *aa*, passes through it from *s s*, so that this and all the connected parts from *b* to *f* can be turned without moving the circle *mm*. The axis *d* passes through a hole in *bc*, so that it can turn the arm *de* into any required position; *f* is a similar axis turning the arm *og*; and *pq* a fourth axis, in like manner movable in *g*, and with a small knob at *q*, to which the crystal to be measured is attached.

When about to use the instrument it should be placed on a table, with its base horizontal, which is readily done by the screws in it, and opposite to a window at about 12 or 15 feet distance, so that its axis shall be parallel to the horizontal bars of the window. One of the upper bars of the window, and also the lower bar, or instead of the latter a white line on the floor or table parallel to the window, should then be chosen in order to adjust the crystal. The observer

places himself behind the instrument with the side *a* at his right hand. The crystal is then attached to *q* by a piece of wax with the two faces to be measured upwards. The axis *fo* is made parallel to *aa*, and the eye being brought near to the first face of the crystal, the axes *aa* and *p* are turned till the image of the window is seen reflected in the face with the horizontal and vertical bars in their proper position. The axis *d* is then turned through a considerable angle (say 60°), and the image of the window again sought and brought into its proper place by turning the axis *f*, without moving *p*. When this is done that face is brought into its true position, normal to *d*, so that no motion of *d* can disarrange it. Hence the image of the window may now be sought in the second face and brought into its true position, with the horizontal bars seen horizontal, by moving the axes *d* and *a*. When this is done the crystal is properly adjusted, and the angle is thus measured. First bring the zero of the circle and vernier to coincide, and then turn the inner axis *a* or *ss* and move the eye till the image of the upper bar of the window reflected from the more distant face of the crystal coincides with the lower bar or horizontal line seen directly. Keeping the eye in its place, turn the outer axis *tt* till the reflected image of the upper bar in the other face in like manner coincides with the lower line, and the angle of the two faces is then read off on the divided circle. As the angle measured is not directly that of the faces, but of the rays of light reflected from them, or the difference of the angle wanted from 180°, the circle has the degrees numbered in the reverse direction, so as to give the angle without the trouble of subtracting the one from the other.

The above apparatus for adjusting the crystal is an improvement suggested by Naumann. In the original instrument the axis *fo* was made to push in or out in a sheath, and had a small brass plate, bent at right angles, inserted in a cleft at *o*, to which the crystal was attached. The crystal was adjusted as formerly by moving the plate, or the axis *fo*, and by slight motion of the arm *de*, which should be at right angles nearly to *bc* when used. A considerable improvement is to have a small mirror fixed on the stand below the crystal, with its face parallel to the axis *aa*, and inclined at 45° to the window, when the lower line can be dispensed with, and the instrument used for various other purposes of angular measurement. Many alterations have been suggested for the purpose of insuring greater accuracy, but the simple instrument is sufficient for all purposes of determinative mineralogy, and the error from the instrument will, in most cases, be less than the actual variations in the dimensions of the crystals. Greater simplicity is indeed rather desirable, and the student will often find it sufficient to attach the crystal by a piece of

wax to the axis a directly, and give it the further adjustment by the hand. The only use of the parts from b to q is to enable the observer to place the crystal properly; that is, with the edge to be measured parallel to the axis of the instrument, and as nearly as possible coinciding with its centre. This is effected when the reflection of the horizontal bar in the two faces appears parallel to that edge.

Macles or Twin Crystals.

When two similar crystals, or individuals of a mineral species, are united together with their similar faces and axes parallel, the one forms merely a continuation or enlargement of the other, and both may be regarded as constituting only one individual. Frequently, however, two crystals are united according to very precise laws, though all their similar faces and axes are not thus parallel. Compound crystals of the latter kind are named macles or twin crystals; and are divided into those in which the axes of the two crystals are parallel, and those in which they are inclined. The former only occur among hemihedric forms and combinations, and the two forms are then combined in the exact position in which they would be derived from or reproduce the primary holohedric form. The second class, with oblique axes, occur both in holohedric and hemihedric forms. According to Weiss they are all regulated by the general law, that the two individuals are placed in perfect symmetry to each other, in reference to a particular face of the crystal which forms the plane of union or the equator of the macle. The same law results when we suppose the two crystals originally parallel and the one turned round the normal of the united faces by 180°, whilst the other is stationary. Or we may suppose a crystal cut into halves in a particular direction, and one half turned 180° on the other, and hence the name of hemitrope given to them by Hauy. The position of the two individuals in this case is the same with that of an object and its image in a mirror, whose surface then represents the plane of union.

The manner in which the crystals unite also differs. Some are merely opposed or in simple contact by two faces; others are as it were grown together and mutually interpenetrated, and are occasionally so completely incorporated as to appear like one single individual. The twin-edges and angles in which the two unite are often re-entering; or they may coincide in one plane, when the line of union is either imperceptible or is only marked by the meeting of two systems of striæ, or other diversity in the physical characters of the two faces.

The formation of twin crystals may be again repeated, forming groups of three, four, or more. When the faces of union are parallel to each other, the crystals form rows of indeterminate extent; where they are not parallel they may return into each other in circles or

form bouquet-like or other groups. Where crystals are merely in juxtaposition they are sometimes much shortened in the direction of the twin axis; and where many occur in a series with parallel position, are often compressed into very thin plates, frequently not thicker than paper, giving to the surface of the aggregate a peculiar striated aspect.

Only a few twin crystals in the different systems can be noticed, chiefly as examples of this mode of formation, and not as a complete enumeration. In the tesseral system only the tetrahedral and dodecahedral hemihedric forms unite with parallel axes, and then produce intersecting macles like the pentagonal dodecahedrons of iron pyrites in fig. 74, and the tetrahedrons of grey copper or fahl-ore in fig. 75, a

Fig. 74.

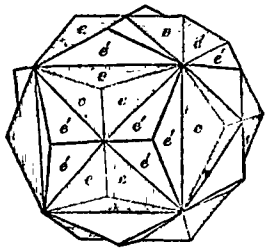
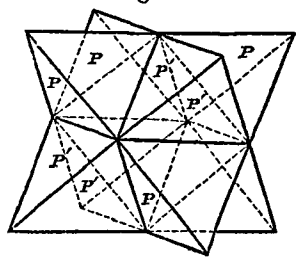


Fig. 75.



similar formation also occurring in the diamond. In macles with inclined axes the two forms almost always unite by a face of the octahedron, and the two individuals are then generally apposed and shortened in the direction of the twin axis by one-half, so that they appear like a crystal that has been divided by a plane parallel to one of its faces, and the two halves turned round on each other by an angle of 180°. In this manner two octahedrons of the spinel, magnetic iron ore,

Fig. 76.

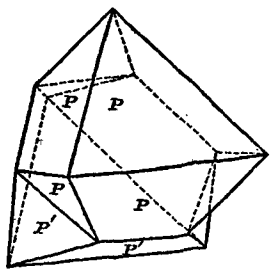
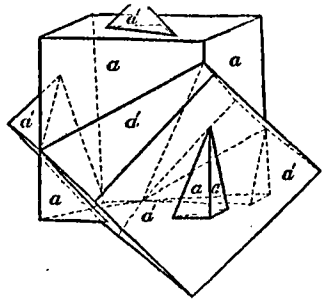


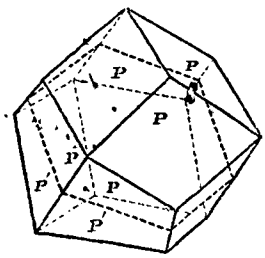
Fig. 77.



or automolite, (fig. 76), are frequently united. The same law pre-

vailing the intersecting cubes of fluor spar, iron pyrites, and galena, represented in fig. 77. In fig. 78 of zinc blende two rhombic dodecahedrons are united by a face of the octahedron.

Fig. 78



In the tetragonal system, twin crystals with parallel axes rarely occur, because few of the species belonging to it present hemihedric forms. It is, however, seen in copper pyrites, and one or two other minerals. Where the axes are inclined the plane of union is very often one of the faces of the pyramid P∞, or one of those faces that would regularly replace the polar edges of the fundamental form P. The crystals of tin ore obey this law, as seen in fig. 79, where the individuals are pyramidal, and

Fig. 79.

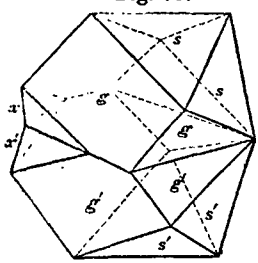
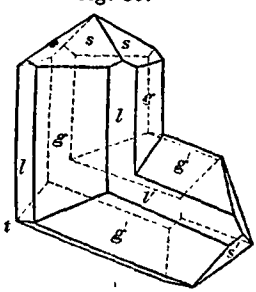
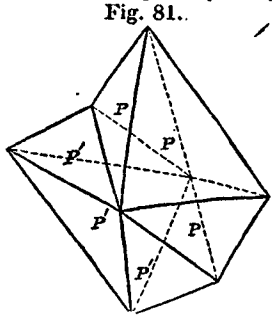


Fig. 80.



in the knee-shaped crystal (fig. 80), where they are more prismatic. Rutile also occurs like the latter figure; and in both species three, four, or more crystals are frequently united. Hausmanite appears like fig. 81, in which the fundamental pyramid P prevails, on whose polar edges other crystals are often very symmetrically repeated, a central individual appearing like the support of all the others. Almost identical forms occur in copper pyrites.

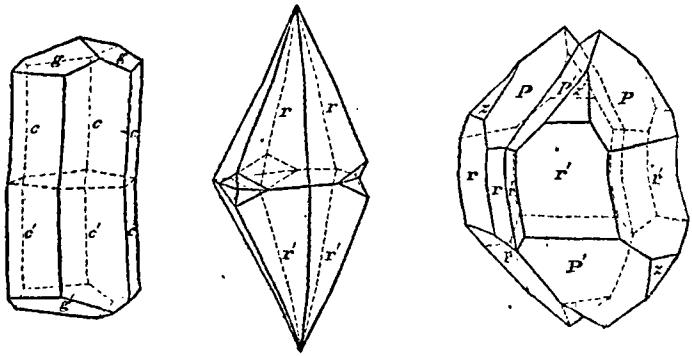
Fig. 81.



In the hexagonal system twin crystals with parallel axes are common, as in calc-spar, chabasite, specular iron, and other rhombohedric minerals. In calc-spar they often form very regular crystals, the two individuals uniting by a plane parallel to the base, so as to appear like a single crystal, as in fig. 82, where

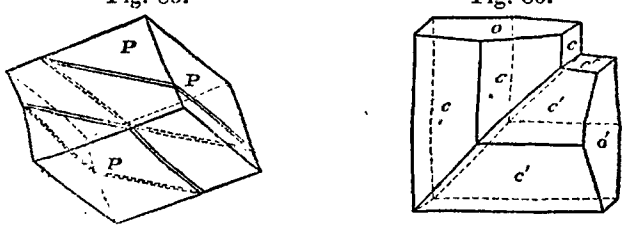
each end shows the forms R. $-\frac{1}{2}$R, but in a complementary position; or in fig. 83 of two scalenohedrons R^3 from Derbyshire. The rhombohedric crystals of chabasite often appear intersecting each other, like those of fluor spar in fig. 77 above. The purer varieties of quartz or rock crystal in consequence of the tetartohedric character of its crystallization often exhibit twins. In these the pyramid P

Fig. 82. Fig. 83. Fig. 84.



separates into two rhombohedrons, *P* and *r*, which, though geometrically similar, are yet physically distinct. In fig. 84 the two individuals are only grown together, but more commonly they penetrate each other in an irregular manner, forming apparently a single crystal. Twins with oblique axes are also common, the plane of union being usually one face of the rhombohedron. Thus in calc-spar two rhombohedrons are often joined by a face of $-\frac{1}{2}$R, the two axes forming an angle of 127° 34′; occasionally a third individual is interposed in a lamellar form, as in fig. 85, when the two outer crystals become parallel. This latter arrangement is very common in the highly

Fig. 85. Fig. 86.

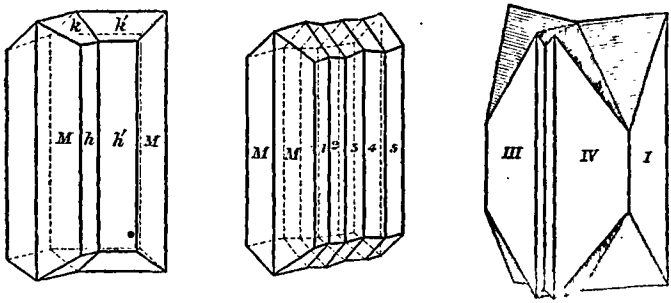


cleavable varieties of Iceland spar. When the crystals unite in a face of the rhombohedron R, fig. 86, they form an angle of 89° 8′, differing little from a right angle by which the occurrence of this law is very easily recognised, especially in prismatic varieties.

In the rhombic system, twin crystals with parallel axes are very

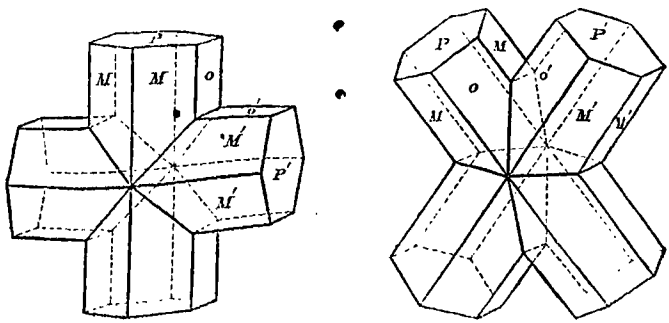
rare, but those with oblique axes common, the plane of union being one of the faces of the prism ∞P. Twins of this kind are very distinctly seen in arragonite, carbonate of lead, marcasite, the melane or silver glance, mispickel, and other minerals. In arragonite the crystals partly interpenetrate, partly are in mere juxtaposition, as in fig. 87, where the individuals are formed by the combination ∞P(*M*) . ∞P̆∞ (*h*) . P̆∞ (k); and in figure 88, where several crystals of the same combination form a series with parallel planes of union; the

Fig. 87. Fig. 88. Fig. 89.



inner members being so shortened that they appear like mere lamellar plates producing striæ on the faces P̆∞ and ∞P̆∞ of the macle. In figure 89 four crystals, each of the combination ∞P . 2P̆∞, having united in inclined planes form a circular group returning into itself. The carbonate of lead often occurs in macles in all respects similar. In staurolite individuals of the prismatic combination ∞P . ∞P̆∞ . 0P, combine either as in fig. 90 by a face of the brachydome ⅔P̆∞ with

Fig. 90. Fig. 91.



their chief axes almost at right angles; or as in fig. 91 by a face of

the brachypyramid $\frac{3}{2}\breve{P}^{3}$, the chief axes and the brachypinakoids (o) of the two single crystals meeting at an angle of about 60°. Finally, in fig. 92 two harmotome crystals of the most common combination, $\infty\breve{P}\infty$. $\infty\bar{P}\infty$. P. $\breve{P}\infty$, intersect each other so nearly at right angles, that their principal axes seem to coincide, and the brachypinakoid (q) of the one crystal (with rhombic striæ) is parallel to the macropinakoid (o) of the other. This seems the true interpretation of this somewhat difficult form.

Fig. 92.

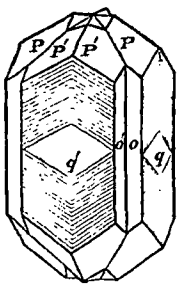


Fig. 93.

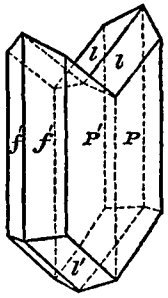
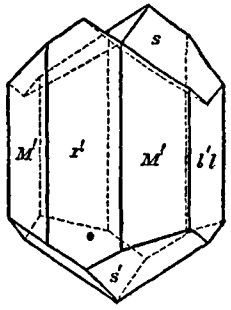


Fig. 94.



In the monoclinohedric system the most common macles are those in which the principal axes and the chief sections of the two crystals are parallel to each other, and consequently the principal axis also the twin axis. Usually the two individuals are united by a face parallel to the orthodiagonal chief section, as in this figure 93 of gypsum, where two crystals of the combination (∞P∞) . ∞P . —P, shown in fig. 63 above, unite so regularly that the faces of the pinakoids (P and P') form only one plane. In a similar manner the augite crystals of the combination ∞P . ∞P∞ . (∞P∞). P, represented singly in fig. 64 above, are in fig. 94 united in a macle so very symmetrical and regular that the line of junction cannot be observed on the face of the clinopinakoid. The two hemipyramids P (s) (like —P (l) in the gypsum crystal above, form on one side a re-entering, on the other a salient angle. Hornblende, wolfram, and other minerals exhibit a similar appearance. In other cases the individuals partially penetrate each other, being as it were crushed together in the direction of the orthodiagonal. This mode of union is not uncommon in gypsum, and very frequent in the orthoclase and ryacolite felspars. Two crystals of the former with the combination (∞P∞) . ∞P . 0P . 2P∞, as in fig. 65 above, are often pushed sidewise into each other as shown in this fig. 95.

In the triclinohedric system some twin formations are of great importance as a means of distinguishing the triclinohedric from the mo-

noclinohedric species of felspar. In one variety the twin axis is the normal to the brachydiagonal chief section. But in the triclinohedric felspars this section is not, as it is in the monoclinohedric species, perpendicular to the basis, and consequently the two bases form on one side a re-entering, on the other a salient angle; whereas

Fig. 95.

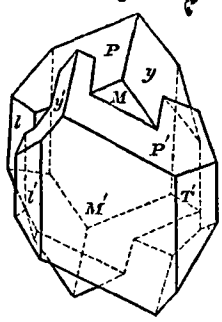
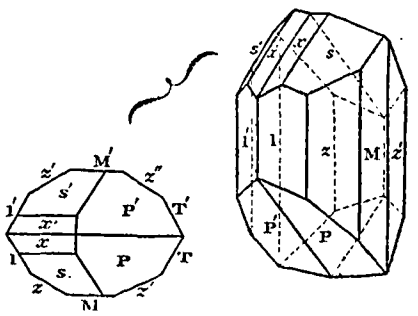
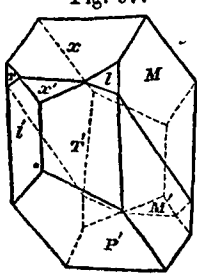


Fig. 96.



in the monoclinohedric felspars (where the brachydiagonal chief section corresponds to the clinodiagonal) no twin crystals can be produced in conformity to this law, and the two bases fall in one plane. The albite and oligoclase very often exhibit such twins, as in figure 96, where the very obtuse angles formed by the faces of 0P, or P and P' (as well as those of $\breve{P}'\infty$, or x and x') are a very characteristic appearance, marking out this mineral at once as a triclinohedric species. Usually the twin formation is repeated, three or more crystals being combined, when those in the centre are reduced to mere plates. When very numerous, the surfaces P and x are covered with fine striæ, often only perceptible with a microscope. A second law observed in triclinohedric felspars, particularly the albite and labradorite, is that the twin axis corresponds with that normal of the brachydiagonal, which is situated in the plane of the base. In pericline, a variety of albite, these twins appear as in fig. 97, where the two crystals are united by a face of the basal pinakoid P, whilst the faces of the two brachypinakoids (M and M') form edges with very obtuse angles (173° 22′), re-entering on the one side, and salient on the other. These edges, or the line of junction between M and M', are also parallel to the edges formed by these faces and the base, or those between M and P. In this case also the macles are occasionally several times

Fig. 97.



repeated when the faces in like manner appear covered with fine striæ.

Irregular Aggregation of Crystals.

Besides the regular unions now described, crystals are aggregated in peculiar ways, to which no fixed law can be assigned, but which are nevertheless very interesting in relation to the complete history of the mineral kingdom. Some crystals, apparently simple, are composed of concentric crusts or shells, either intimately united, loosely superimposed, or divided by a layer of dust or a thin film of some different material. Such appearances are well seen in some large crystals of wolfram from Zinnwald, and of pistacite from Arendal, in which shell after shell may be removed from the surface, each leaving a smaller crystal like a kernel, with smooth distinct faces. Some specimens of quartz from Beeralston in Devonshire consist apparently of hollow hexagonal pyramids of quartz placed one within another. In fluor spar a dark blue rhombic dodecahedron is sometimes seen, as it were, imbedded like a kernel in a cube of a pale green colour. Other minerals, as apatite, heavy spar, and calc-spar, exhibit a similar structure, bands of different colours being separated by planes parallel either to the external surface or to certain faces of the crystal. This structure seems to have resulted from the process of crystallization having been occasionally interrupted.

Many large crystals appear like an aggregate of numerous small crystals, partly of the same, partly of different forms, all united in a parallel position. Thus some octahedrons of fluor spar from Schlaggenwald are found to be made up of small dark violet-blue cubes, all in a parallel position, whose projecting angles give a drusy character to the faces of the larger form. Such polysynthetic crystals, as they may be called, are very common in calc-spar Breithaupt has also shown that frequently distinct forms of different varieties of one and the same mineral species, as, for example, calc-spar or heavy spar, are aggregated in a parallel position. In this case, some change must have taken place in the nature of the fluid, from which they crystallized, causing the crystals subsequently produced to assume a different form, colour, and specific gravity, though their formation was still so far regulated by their first crystals that their axes are all parallel. Such crystals are said to be of a double or twofold formation.

A similar, but still more remarkable, formation is where two crystals of distinct species are conjoined. Such unions of cyanite and staurolite have been long well known, one face and axis of each mineral being parallel. Breithaupt has described some interesting unions of iron-glance and rutile, in which small crystals of the latter are so imposed on a large crystal of the former, that the chief axis and certain

planes of the rutile are parallel to the intermediate axes and certain planes of the iron-glance, or six crystals of rutile radiate, as it were, from a hexagonal face of iron-glance. The graphic-granite exhibits a similar union between large felspar crystals, and many smaller ones of mica and quartz. The cockscomb pyrites, a remarkable twin variety of the rhombic iron pyrites or marcasite, is often sprinkled with small crystals of the cubical pyrites placed in a determinate position relative to the former. Haidinger first recognized, in the so-called smaragdite, of a grass-green colour from Bacher, a very common conjunction of hornblende and augite, in which lamellæ of the two species alternate, the chief axes and orthodiagonals of the different laminæ of each mineral being parallel, but those of the hornblende and augite not parallel. The fine drusy covering of copper pyrites, sometimes seen on fahl-ore and zinc blende, is also of a similar character; on the other hand, some crystals from Kapnik, which externally seem to consist of blende, when broken contain a kernel of copper pyrites.

Forms of Crystalline Aggregates.—In the cases hitherto described, the connection of two or more crystals has been regulated by certain fixed and determinate laws. But in other instances, no such law can be observed, and two or more individuals are conjoined apparently for no other reason than their accidental formation in the same place. Many of these aggregates, however, present very interesting characters. Three varieties of them may be distinguished: one in which the individuals can be easily recognized, and have been able, at least partially, to crystallize with freedom. In the second, the parts composing the mass are still distinctly crystalline, but have nowhere formed free crystals. In the third, the different parts are so minute, that even though they may be crystalline in structure, yet this cannot be discerned, and they have therefore been named crypto-crystalline. Where the parts are still discernible, the aggregates differ according to their general configuration. They are named *granular* when formed of grains, generally angular, but rarely rounded or flattened. The *lamellar* consist of broad plates, which are *tabular* when of uniform thickness, *lenticular* when becoming thinner on the edges, *wedge-shaped* when sharpened towards one edge, and *scaly* when the plates are very small. The third type is the *columnar*, in which the individuals are drawn out in one direction more than in the others; the *bacillary* or rod-like, in which the columns are of uniform thickness; the *acicular* or needle-shaped, in which they are pointed; and the *fibrous*, in which they are very fine, being distinguished. In the broad-columnar the columns are, as it were, compressed, or broader in one direction than the other. The distinctions of large, coarse, small or fine granular; thick or thin scaly; straight, curved, or twisted columnar;

parallel, diverging, or confused fibrous; and such like are either easily understood or can only be explained by specimens.

Aggregates which have been able to crystallize, at least, with a certain degree of freedom, have been distinguished by Mohs into crystal groups and druses, the former including all unions of several imbedded crystals, the latter those of crystals that have grown together on a common support. In the groups, crystals with their faces otherwise perfect are conjoined in various ways. Sometimes they radiate, as it were, from a common centre, and produce spheroidal, ellipsoidal, or other forms, frequent in gypsum, iron pyrites, and other minerals imbedded in clay. Where many such masses are united they are named *botryoidal* when like bunches of grapes, *mammellated* where the spheres are larger and less distinct, and *reniform* or kidney-shaped where the masses are still larger. Some groups are partially attached by a small point, but the mass generally free.

Crystals are often grouped in rows or in one direction, forming, when they are very small, capillary or hair-like, and filiform, thread, or wire-like forms, which are common among native metals, as gold, silver, copper, and bismuth, in silver-glance and a few other minerals. Sometimes the masses are dentiform, consisting of portions resembling teeth; as is very common in silver, a specimen of this kind from Konigsberg in the collection at Copenhagen weighing four pounds. Often these groups expand in several directions, and produce arborescent, dendritic, foliated, feathered, or other forms. These are very common in native copper, some beautiful examples being figured by G. Rose in his work on the Ural mountains. In these forms, however, a certain dependence on the crystallographic character of the species may be observed. The lamellar minerals often form fan-shaped, wheel-like, almond-shaped, comb-like, or other groups. The fibrous types again are disposed in parallel or diverging bundles, or in radiating, stellar, and other masses. Coralloidal, like coral, fruticose, like cauliflower and other forms, have also been observed.

In druses, many crystals rise side by side from a common support, sometimes only the granular mass composed of their united bases, at other times some distinct body. The form of a druse is determined by that of the surface on which it grows, and consequently is often very irregular or wholly accidental. Where completely enclosed they have been named drusy cavities, and when of a spheroidal form geodes. A drusy crust again consists of a thin layer of small crystals, investing the surface of a large crystal or of some other body.

The minute or cryptocrystalline minerals form similar aggregates. Of these the globular or the oolitic is one of the most remarkable. In

it, the minute crystals often appear to radiate from a centre, or form concentric crusts. In the well-known peastone from the hot springs of Carlsbad, the mineral, a kind of arragonite, has usually collected round a grain of sand, often of granite, which has been kept floating about by the motion of the water till it became too heavy from the accumulated matter. Somewhat similar are the stalactites and stalagmites, in which the mineral, especially rock-salt, limestone, chalcedony, opal, limonite, has been deposited from a fluid dropping slowly from some overhanging body. In this case the principal axis of the figure, generally a hollow tube, is vertical, whilst the individual parts are arranged at right angles to this direction. In other cases the mineral has apparently been deposited from a fluid mass, moving slowly in a particular direction, which may be regarded as the chief axis of the figure, whilst the axes of the individual crystals frequently assume a different position.

By far the largest masses of the mineral kingdom have, however, been produced under conditions in which a free development of their forms was excluded. This has been the case with the greater portion of the minerals composing rocks or filling veins and dykes. The structure of these masses on the large scale belongs to geology, but some varieties of the texture visible even in hand specimens may be noticed in this place. The individual grains or masses have seldom any regular form, but appear round, long, or flat, according to circumstances, and as each has been more or less checked in the process of formation. Even then, however, a certain regularity in the position of the parts is often observable, as in granite, in which the cleavage planes and consequently the axes of the felspar crystals are parallel. Where these grains are all pretty similar in size and shape, the rock is named massive when they are small, or granular when they are larger and more distinct. Sometimes the rock becomes slaty, dividing into thin plates; or concretionary, forming roundish masses; at other times the interposition of some foreign substance (gas or vapour) has rendered it porous, cellular or vesicular, giving rise to drusy cavities. These cavities are often empty, but have occasionally been filled by other minerals when the rock is named amygdaloidal, from the almond-like shape of the inclosed masses.

Many of the above external forms appear also in the amorphous solid minerals, in which no trace of individual parts, and consequently of internal structure, is observable. They are not unfrequently disposed in parallel or concentric layers, of uniform or distinct colours; and may assume spherical, cylindrical, stalactitic, and other appearances. As already stated, it is probable that many so-called amor-

phous bodies consist of crystalline parts, though these are too minute for our means of observation.

Pseudomorphism.—Closely connected with this subject and themselves of great interest are the pseudomorphic minerals. These are often very improperly named crystals, though only resembling them in external form, and possessing none of their essential properties. A better name would be crystalloids, indicating that the substance is of one, whilst the form is that of another mineral species. One class named hypostatic pseudomorphs have been formed by the deposition of the new substance on the surface of the first mineral; and that either on its exterior surface (exogene), or in the interior (esogene); or in both directions (amphigene pseudomorphs). The first or incrusting pseudomorphs sometimes retain the original crystal in the centre, covered by a rough or drusy surface of the second frequently not thicker than paper. Occasionally the first crystal has been removed, and nothing but the shell remains; or a new deposition towards the interior has taken place, often also leaving a drusy cavity within. At other times the cavity has been filled by a distinct mineral species, and the crust having been subsequently removed, an exact representation of the original crystal, but of a different substance, remains. Such pseudo-crystals may be drusy in the interior, or show their true nature from the individual parts being all turned in an inward direction. The existence of such pseudomorphous formations has been denied by Haidinger and others, but probably without sufficient reason, though the process is indeed somewhat complicated.

A more common variety of pseudomorph is where the new mineral substance has gradually expelled the old, the same chemical process that removed the matter of the original crystal having replaced it, as it were, atom by atom, with another substance which has assumed its exact form. The true nature of such bodies is shown by the internal structure, having no relation to the external form or apparent system of crystallization.

Somewhat diverse from these are those named metasomatic pseudomorphs, in which not the whole substance of the original crystal, but only one or more of its elements has been changed, or the whole matter has remained, but in a new condition. Thus arragonite crystals have been converted into calc-spar, the chemical composition of both being identical; or gaylussite has been changed into calc-spar, andalusite into cyanite, by the loss of certain elements. On the other hand, anhydrite becomes gypsum, red copper ore malachite, by addition of new matter. Or the elements are partially changed, as felspar into kaolin, quartz or pearl spar into talc, iron pyrites or iron glance into brown iron ore, azurite into malachite, augite into green-earth. Many other

singular pseudomorphs have been described, but these are sufficient for our present purpose.

Haidinger gives the following somewhat different view and division of pseudomorphs. The original crystal may be supposed subsequently placed in a stream capable of effecting its decomposition, which has removed certain elements, and left the remainder undissolved in the form as on a filtre, or has brought others with it, which were precipitated from the solution by the original matter and either remained behind with this or in its place. On comparing the two minerals, the first, as known by its form, the second as still observed, they may be considered as two points in an electrochemical series, from which we may determine whether the change has caused oxidation or reduction, has been electronegative or electropositive.

The influence of the oxygen of the atmosphere produces in general oxidized pseudomorphs, or those proceeding in an electronegative direction, nearer the surface of the earth; the absence of this influence reduced pseudomorphs, or those proceeding in an electronegative direction at greater depths. These two classes may thus from their geognostic position, be named anogene (from ἄνω upwards) and katogene (κατω downwards), these terms also expressing their relation to the degree of pressure, and to the galvanic poles, of which the zinc at which oxygen is developed has the name of anode, the copper producing hydrogen the kathode.

The following are a few examples of these two formations. In the anogene, quartz following calc spar, or, as in some specimens from Bristol, investing it as a crust. At Beeralston, Devonshire, hornstone has followed after fluor spar, and at Kapnick, in Siebenburg, blue chalcedony has the form of cubes of fluor spar. In the same class are limonite or the oxyhydrate of iron in the place of the carbonate or either of the two pyrites; malachite, as at Chessy, in place of the azurite; and calc spar after arragonite, as in the petrified wood from Schlackenwerth in Bohemia. Of the katogene pseudomorphs, one of the most common is gypsum or anhydrite in place of rock salt. Others are prehnite after analcime (in the Kilpatrick hills), or after laumonite, or natrolite; brown spar or dolomite after calc spar; the uralite or hornblende in the form of augite; kaolin after felspar and some others. In the kaolin a great part of the silica, the most electronegative element, is wanting.*

The process of petrifaction of organic bodies is in reality a species

* See Landgrebe, Ueber die Pseudomorphosen im Mineralreich, Cassel 1841; Blum, die Pseudomorphosen des Mineralreiches, Stuttgart, 1843, &c. Nachtrage, 1847. Haidinger in Poggen Ann. vol. lxii. (1844) p. 161.

of pseudomorphic formation, and has been produced in all the above modes. External and internal casts of organic bodies are not uncommon, and the body being subsequently destroyed its place is now either vacant or filled by some mineral substance. In others the original substance has been completely replaced by some mineral which has preserved not merely the external form, but even the minutest detail of internal structure; so that the different kinds of wood have been distinguished in their silicified trunks. The most common petrifying substances are silica and carbonate of lime. In encrinites, echinites, belemnites, and other fossils, the crystals of the latter often occur in very regular positions. Thus a single crystal forms some particular part, as one of the spines of the cidarites, with its axis parallel to that of the spine. Each joint of the encrinite stems also consists of a single individual of calc spar with its axis parallel to that of the stem, whether this is round or pentagonal. In the latter case a cleavage plane proceeds from one of the horizontal edges, and in the next joint from one of the neighbouring edges of the pentagon, so that the calc spar crystals, their axes remaining in a similar position, have yet been turned 72° round on each other. This, though a regular position relative to the organism, is not a macle formed by crystallographic laws. In some varieties of petrified wood both the ligneous structure and the cleavage of the calc spar are observable.

Different from the above are mineralized bodies, in which the original structure is still retained, but their chemical nature partially changed. In these a complete series may be often traced, as from wood or peat, through the varieties of brown coal, common coal, anthracite, and graphite, perhaps even to the diamond.

CHAPTER II.

PHYSICAL PROPERTIES OF MINERALS.

The relations of the crystals and other aggregates described in the previous chapter may be regarded as the mathematical class of mineral characters, depending simply on the form of the space occupied without reference to the matter. The next branch, or their physical characters, comprehends not only those properties derived from the nature of the substance itself, as coherence, mode of fracture, elasticity, and density, or specific gravity, but also those phenomena called forth in minerals by the influence of some external power or agent, as their optical, electric, or thermal relations; and also other characters depending on the personal sensation of the observer, on his taste, smell, and touch. All these properties furnish useful characters in distinguishing and describing mineral species, though the limits of this treatise only allow us to point out those peculiarities which are of chief importance, and which might not otherwise be readily understood.

Cleavage and Fracture.

Minerals are found to vary much in the degree of coherence existing among the parts of which they consist, and whilst some can with difficulty be broken, others yield to the slightest blow. Even in the same species cohesion varies in different directions, and there are certain planes at right angles to which it seems to be at a minimum, so that the mineral separates along or parallel to these planes far more readily than in any other direction. This property is named cleavage, and the planes thus formed cleavage-planes. The latter are in general smooth and even, and exist in equal perfection in every portion of the crystal. They have also a very definite position, and do not show any transition or gradual passage into the greater coherence in other directions. The number of these cleavage planes is altogether indefinite, and in some minerals, as gypsum and mica, the only limit that can be assigned to their divisibility into laminæ arises from the coarseness of our instruments. This fact proves that these cleavage planes do not actually pre-exist,

but are as it were called forth by the force applied to the mineral. Hence it is improper to describe such minerals as composed or built up of laminæ. These layers have no distinct existence in nature, where we only find a tendency to divide parallel to certain planes, as a consequence of which they are produced on the application of force in the proper direction.

These minima of coherence or cleavage planes are always parallel to certain faces of the crystalline forms, and equal similar minima occur parallel to every other face of the same form. Hence they are always equal in number to the faces of the form, and the figures produced by cleavage agree in every point with true crystals, except that they are artificial and not natural. They are thus most simply and conveniently described by the same terms and signs as crystals. Some minerals cleave in several directions parallel to the faces of different forms, but the cleavage is generally more easily obtained and more perfect in one direction than in the others. This complex cleavage is seen in calc-spar, and fluor spar, and very remarkably in zinc blende, where it takes place in no less than six directions. As in each of these the division may be indefinitely continued, it is clear that no lamellar structure in any proper sense can be assigned to the mineral. All that can be affirmed is, that contiguous atoms have less coherence in the normal of these planes than in other directions. The common cleavage in the different systems is as follows, those of most frequent occurrence being put in italics. (1.) In the tesseral, *Octahedric* O along the faces of the octahedron; *Hexahedric* $\infty O\infty$, along those of the cube; and Dodecahedric ∞O. (2.) In the tetragonal system, Pyramidal P, or $2P\infty$; *Prismatic*, ∞P or $\infty P\infty$; or *Basal* 0P. (3.) In the hexagonal system with holohedric forms, Pyramidal P or P2; *Prismatic*, ∞P or $\infty P2$; or *Basal*, 0P; with rhombic hemihedral forms, *Rhombohedric*, R; Prismatic, ∞R; or *Basal*, 0R. (4.) In the rhombic system, Pyramidal, P; *Prismatic*, ∞P; Makro or Brachydomatic $\breve{P}\infty$ or $\breve{P}\infty$; *Basal*, 0P; Macrodiagonal, $\infty\breve{P}\infty$; or *Brachydiagonal*, $\infty\breve{P}\infty$. (5.) In the monoclinohedric system, Hemipyramidal, P or —P; *Prismatic*, ∞P; Clinodomatic, $(P\infty)$; Hemidomatic, $P\infty$ or $-P\infty$; *Basal*, 0P; *Orthodiagonal*, $\infty P\infty$; or *Clinodiagonal*, $(\infty P\delta)$. (6.) In the triclinohedric system, Hemiprismatic, $\infty P'$ or $\infty'P$; Hemidomatic either along the macrodome or brachydome; *Basal*, 0P; Macrodiagonal, $\infty\breve{P}\infty$; or *Brachydiagonal*, $\infty\breve{P}\infty$.

Minerals differ much in the more or less facility of their cleavage, which in some is readily procured, in others only with extreme difficulty. The planes produced also vary much in their degree of perfection, being *highly* perfect, as in mica and gypsum; *very* perfect

in fluor spar, barytes, and hornblende; perfect in augite and cryolite; imperfect in garnet and quartz; or very imperfect where it is scarcely perceptible. The latter is chiefly marked by the reflection of a strong light from small dispersed points on the fractured surface. In a very few crystalline minerals cleavage planes can hardly be said to exist. Cleavage must be carefully distinguished from the planes of union in twin crystals, and the division planes in the laminar minerals.

When a mineral breaks in a direction different from the cleavage planes it forms fracture surfaces. These are consequently most readily observed when the cleavage is least perfect, whereas in minerals that cleave very easily, in several directions a true fracture surface can hardly be obtained. The form of the fracture is named *conchoidal*, when composed of concave and convex surfaces like shells; *even* when nearly free from inequalities; or *uneven* when marked with numerous irregular elevations and depressions. The character of the surface is *smooth*, when it extends uniformly with few asperities; *splintery* when covered by small wedge-shaped splinters adhering by the thicker end, a form most perceptible in pellucid minerals where the thinner parts are lighter coloured; *hackly*, when covered by small slightly bent inequalities; or *earthy* when it shows only fine dust or sandy parts.

Hardness and Tenacity.

The hardness of minerals, or their power of resisting any attempt to separate their parts, is also an important character. It appears, however, to differ considerably in the same species, according to the direction in which we attempt to scratch the crystal and the surface on which the trial is made. Hence its accurate determination is difficult, and the utmost that can usually be obtained is a mere approximation found by comparing different minerals, one with another. For this purpose Mohs has given the following scale.

1. *Talc*, of a white or greenish colour.
2. *Rock-salt*, a pure cleavable variety, or semitransparent *uncrystallized gypsum*, the transparent and crystallized varieties being generally too soft.
3. *Calcareous spar*, a cleavable variety.
4. *Fluor spar*, in which the cleavage is distinct.
5. *Apatite*, the asparagus stone, or phosphate of lime, from Saltzburg.
6. *Adularia felspar*, any cleavable variety.
7. *Rock-crystal*, a transparent variety.
8. *Prismatic topaz*, any simple variety.
9. *Corundum* from India, which affords smooth cleavage surfaces.

The *Diamond*.

To these Breithaupt has added two other degrees, by interposing foliated mica between 2 and 3, and scapolite, a crystalline variety, between 5 and 6. The former is numbered 2·5, the latter 5·5.

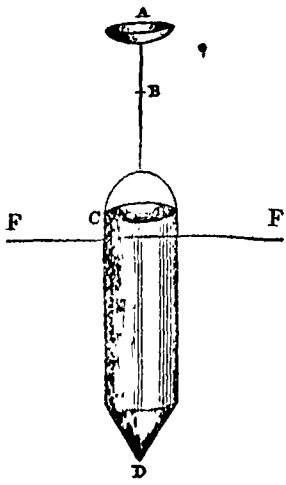
To ascertain the hardness of a mineral, first try which of the members of the scale is scratched by it, and in order to save the specimens, begin with the highest numbers, and proceed downwards, until reaching one which is scratched. Next take a fine hard file, and draw along its surface, with the least possible force, the specimen to be examined, and also that mineral in the scale whose hardness is immediately above the one which has been scratched, in order to compare them together. From the resistance they offer to the file, from the noise occasioned by their passing along it, and from the quantity of powder left on its surface, their relative hardness is deduced. If the two specimens afford the same degree of noise and resistance, and the same quantity of powder, their hardness is the same. When, after repeated trials, we are satisfied to which member of the scale of hardness the mineral is most nearly allied, we say its hardness (suppose it to be felspar) is equal to 6, and write after it H = 6·0. If the mineral do not exactly correspond with any degree of the scale, but is found to be between two of them, it is marked by the lower with a decimal figure added. Thus, if more than 6 but less than 7, it is expressed H = 6·5. In these experiments we must be careful to employ specimens which nearly agree in form and size, and also as much as possible in the shape of their angles.

Closely allied to hardness is the tenacity of minerals, of which the following varieties have been distinguished. A mineral is said to be brittle, when, as in quartz, on attempting to cut it with a knife, it emits a grating noise, and the particles fly away in the form of dust. It is sectile or mild when, as in galena and some varieties of mica, on cutting, the particles lose their connection in a considerable degree; but this takes place without noise, and they do not fly off, but remain on the knife. And a mineral is said to be soft or ductile when like native gold it can be cut into slices with a knife, extended under the hammer, and drawn into wire. From tenacity it is usual to distinguish *frangibility* or the resistance which minerals oppose, when we attempt to break them into pieces or fragments. This property must not be confounded with hardness. Quartz is hard, and hornblende comparatively soft; yet the latter is much more difficultly frangible than the former. Flexibility again expresses the property possessed by some minerals, of bending without breaking. They are elastic like mica, if when bent they spring back again into their former direction; or merely flexible when they can be bent in different directions without breaking, but remain in their new position, as gypsum, talc, asbestus, and all malleable minerals.

Specific Gravity.

The density or the relative weight of a mineral, compared with an equal volume of pure distilled water, is named its specific gravity. This is a most important character for distinguishing minerals, as it varies considerably in different species, and can be readily ascertained with much accuracy, and, in many cases, without at all injuring the specimen. The whole process consists in weighing the body, first in air, and then immersed in water, the difference in the weight being that of an equal bulk of the latter fluid. Hence, assuming, as is commonly done, the specific gravity of water to be equal to 1 or unity, the specific gravity (G) of the other body is equal to its weight in air (w), divided by the loss or difference (d) of weight in water (or $G = \frac{w}{d}$). One of the simplest and most portable instruments for finding the specific gravity is the areometer of Nicholson, fig. 98. It consists of a hollow cylinder C D, loaded at D with lead, so as to float upright in water at about the depth of F F. There is a cup at C, and another connected by a wire with the cylinder, at A, in which any body may be placed. In using this instrument, weights are first placed in A till it sinks in the water to the normal point marked B on the wire. The mineral is then placed in A, and the point B again brought to coincide with the surface of the water, by removing a portion (w) of the weights in A, which of course gives the weight of the specimen in the air. It is then removed to C, and the weight (d), which must now be added to that in A to bring the point B to the surface of the water, is equivalent to the weight of this fluid which the mineral has displaced, and the specific gravity is found by dividing the second (w) by the third (d) as above. A delicate hydrostatic balance gives the gravity with far more accuracy; and even a good common balance is often preferable. The mineral may then be suspended from one arm or scale by a fine silk thread or hair, and its weight ascertained first in the air and then in water.

Fig. 98.



There are a few precautions necessary to insure accuracy. Thus a pure specimen must be selected, which is not intermixed with other

substances, and when weighed in air it should be quite dry. It must also be free from cavities, and care must be taken that, when weighed in water, no globules of air adhere to its surface, which render it lighter. If the body imbibes moisture, it should be allowed to remain till fully saturated before determining its weight when immersed, and it is sometimes even necessary to boil the specimen in order to expel the air from its pores. Very porous substances, like pumice, require to be pulverized before their true gravity can be ascertained. Small crystals or fragments, whose freedom from mixture can be seen, are best adapted for this purpose. The specimen experimented on should not be too heavy, thirty grains being enough where the gravity is low, and even less where it is higher. It is also of importance to repeat the trial, if possible with different specimens, which will show whether any cause of error exists, and to take the mean of the whole. A correction should be made for the variation of the temperature of the water from 60° Fahr., which is that usually chosen as the standard in mineralogical works. Where the difference, however, does not exceed ten or fifteen degrees, this correction may be neglected, as it only affects the third or second decimal figure of the result.

Optical Properties of Minerals.

There are few more interesting departments of science than the relations of mineral bodies to light, and the modifications which it undergoes either when passing through them or when reflected from their surface. In this place, however, we can only notice these phenomena so far as they point out distinctions in the internal constitution of minerals, or furnish characters for distinguishing one species from another.

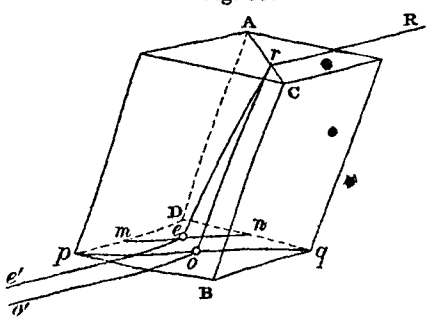
Minerals, and even different specimens of the same species, vary much in the quantity of light which can pass through them. Some transmit so much light, that small objects can be clearly seen, or letters read when placed behind them, and are named *transparent*. They are *semi-transparent* when the object is only seen dimly, as through a cloud; and *translucent* when the light that passes through is so obscured that objects can be no longer discerned. Some minerals are only thus *translucent on the* thinnest *edges*, and in others even these transmit no light, and the body is named *opaque* or untransparent. It is apparent that these degrees pass gradually into each other, and cannot be separated by any precise line. And this is also the case in nature, where a mineral may be seen passing through the whole scale, as quartz from the fine transparent rock crystal to the opaque dark black varieties. This change generally arises from some mixture in their composition, especially of metallic substances. Minerals composed of minute crystalline parts are also generally less transparent

than when the parts are larger or the mineral amorphous. Perfect opacity is chiefly found in the metals or their compounds with sulphur. But even these seem to transmit light when reduced to laminæ of sufficient thinness; though the uniformity of the blue colour observed in thin plates of very different metals would rather imply that it arose from the interference of the rays passing through minute pores.

Double Refraction.—More important are those modifications, as double refraction and polarization, which the rays of light undergo in passing through crystals, but which have not been observed as produced by amorphous bodies. As is well known, when a ray of light passes obliquely from one medium into another of different density, it is bent or refracted from its former course. The line which it then follows forms an angle with the perpendicular, which, in each body, bears a certain proportion to that at which it fell upon it, or, as definitely stated, the sine of the angle of refraction has always a fixed ratio to the sine of the angle of incidence, this ratio being named the index of refraction. This simple refraction is common to all transparent bodies, whether crystalline, amorphous, or fluid, but the greater number of crystals produce a still more remarkable result. The ray of light which entered them as one is divided into two rays, each following different angles, or is doubly refracted. In crystals of the tesseral system this property does not exist, but it has been always observed in minerals belonging to the other systems, though in many cases only after they have been cut in a particular manner, or have been otherwise properly prepared. It is most distinctly seen in crystals of calc-spar, especially in the beautiful transparent variety from Iceland, in which it was first observed and described by Erasmus Bartholin in a work published at Copenhagen in 1669.

The subjoined figure will illustrate this singular property. It represents a rhomb of Iceland spar, on the surface of which a ray of light *Rr* falls. As seen in the figure, this ray divides into two, one of which *roó* follows the ordinary law of refraction, or the sines of the angles of incidence and refraction maintain a constant ratio. This is named the ordinary ray O. The other, hence named the extraordinary ray E,

Fig. 99.



does not obey the usual law of the sines, and has no general index of refraction, except in the plane perpendicular to the axis. In that plane it is most widely separated from the ordinary ray, but in others oblique to it approaches nearer to O, and in one at right angles coincides. This plane or rather direction, in which there is no double refraction, is named the optical axis of the crystal, or the axis of double refraction. Now, in certain minerals it is found that there is only one plane with this property, whereas in others there are two such planes, and they have in consequence been divided into monoaxial and binaxial. To the former class belong all crystals of the tetragonal and hexagonal systems; to the latter all those of the three other systems. In the former the optic axis coincides with, or is parallel to, the crystallographic chief axis; in the latter the two optic axes are placed in the plane of one of the three chief sections, and generally in a symmetrical position relative to its two crystallographic axes. They also form an angle with each other, which varies, not only in different minerals, but also in the varieties of the same species. In some monoaxial crystals with double refraction, the index of refraction for the extraordinary ray E is greater than for the ordinary ray O; and in others it is smaller. The former are said to have positive (or attractive), the latter negative (or repulsive) double refraction. Quartz is an example of the former, the index of refraction, according to Malus, being for O = 1·5484, for E = 1·5582; and calc-spar of the latter, the index of O being = 1·6543, of E = 1·4833. The index of E is in both cases taken at its maximum.

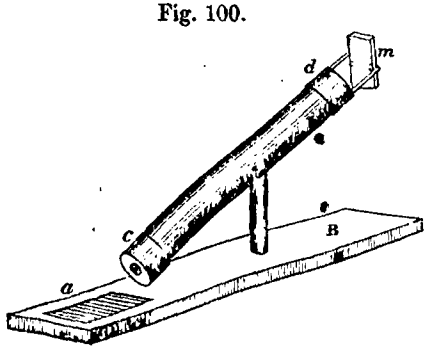
It should be observed that the optic axes are not single lines, but directions parallel to a line, or innumerable parallel lines, passing through every atom of the crystal. It is also important to remark, that this property divides the systems of crystallization into three precise groups,—the tesseral forming one; the tetragonal and hexagonal a second; the other three (or four) systems the third. It is therefore of use to determine the system to which a mineral belongs. But as the angle formed by the optic axes in the several varieties of one and the same binaxial mineral species may vary very much, as is strikingly seen in topas and mica, it is of little use as a character for distinguishing species. Mitscherlich has also shown that it varies in the same specimen with the temperature. According to Fresnel, in the binaxial crystals both rays deviate from the usual direction, so that in reality there is no longer any ordinary ray.

Polarization of Light.—Intimately connected with this property is that of the polarization of light, which, being more easily and precisely observable than double refraction, is of higher value as a mineralogical character. By this term is meant a peculiar modification

which a ray of light undergoes, in consequence of which its capability of being transmitted or reflected towards particular sides is either wholly or partially destroyed. Thus, if from a transparent prism of tourmaline (the green varieties are the best) two thin plates are cut parallel to its axis, they will transmit light, as well as the prism itself, when they are placed above each other, with the chief axis of both in the same direction. But when the one slip of tourmaline is turned at right angles to the other, either no light at all or very little is transmitted, and the plates consequently appear black. Hence in passing through the first slip the rays of light have acquired a peculiar property, which renders them incapable of being transmitted through the second, except in a parallel position, and are hence said to be polarized. The same property is acquired by a ray of light when reflected, at an angle of 35½° (or angle of incidence 54½°), from a plate of glass, one side of which is blackened, or from some other non-metallic body. When such a ray falls on a second similar mirror at an equal angle, but so that the plane of reflection in the second is at right angles to that in the first, it is no longer reflected, but wholly absorbed. When, on the other hand, the planes of reflection are parallel, the ray is wholly and at any intermediate angle partially reflected. A ray of light polarized by reflection is also rendered incapable of transmission through a tourmaline slip in one position, which, however, is at right angles to that in which a ray polarized by passing through another slip is not transmitted. A prism, half an inch thick, of clove-brown rock crystal, acts in the same manner as the tourmaline, but its crystallographic chief axis must be held at a right angle to the former.*

In order to observe the polarization of light, a very simple instrument will be found useful, (fig. 100). At one end of a horizontal board B a black mirror *a* is fixed. In the middle is a pillar to which a tube *cd* is fastened, with its axis directed to the mirror at an angle of 35½°. On the lower end is a cover *c*, with a small hole in the centre, and at the upper end another cover

Fig. 100.



* The angle of polarization varies in each reflecting surface, that given above (54½° from the perpendicular) being for glass. The plane of reflection is also named the plane of polarization, or the ray is polarized in the direction of this plane. A ray is known to be

with a small black mirror attached to it by two arms as in the figure, and also at an angle of 35½°. With this instrument the mirror *d* can be so placed in relation to *a*, that the planes of reflection shall have any desirable inclination to exhibit the simple polarization of light. Its use in determining the polarizing properties of minerals depends on the following principles.

As just stated, polarization may be produced either by reflection or transmission. Thus, when light falls on a glass plate, at the proper angle, part of it is reflected, part transmitted, but both portions polarized, the former in a plane parallel to the plane of incidence, the latter in a direction normal to this plane, or the two rays of light are polarized at right angles to each other. Though tourmaline, as an hexagonal or rhombohedric mineral, possesses double refraction, yet when cut as above mentioned, of a proper thickness, it only transmits the extraordinary ray E, polarized parallel to the basis 0R. A slip of this mineral may therefore be used in place of the mirror *m*, and another also in place of *a*, as in the experiment lately mentioned. Whenever double refraction takes place, the two rays, O and E, are polarized at right angles to each other; O in a plane parallel, E in one normal, to the optic chief section of the surface of incidence. A simple proof of this is obtained by fixing a rhomb of calc-spar over the hole in *c* now placed on the upper end of the tube, and allowing the light to pass through it and be reflected at *a*. Two images of the opening *c* will be seen, and on turning *c* it will be observed that the maximum intensity of the image from O corresponds with the minimum from E, and the reverse. When, however, a ray of light passes through a crystal in the direction of an optic axis, the polarization of the light disappears along with the double refraction, the ray acting like common light.

This property furnishes a simple test whether minerals, that cleave readily in one direction into thin lamellæ, are optically monoaxial or binaxial. Place the two mirrors in the above apparatus with their polarization-planes at right angles, and fix the plate of the mineral to be tried with a little wax over the hole *c*, and then observe what takes place in the second mirror during the time that the cover *c* is turned round. If the mineral belongs to the binaxial system, the light from the first mirror *a*, in passing through it, is doubly refracted and has its polarization changed, and consequently can be again reflected from the second mirror, and in each revolution of *c* will show four maxima and four minima of intensity. If, on the contrary, the

polarized if, when received on a mirror at an angle of incidence of 54½°, it is found that, whilst the mirror is once turned round, it shows two maxima and two minima of intensity of reflection.

mineral is monoaxial, the ray will pass through the lamina unaltered, and will not be reflected from the second mirror in any position of *c*.

That this must be the case is evident on the following grounds. If the lamina belongs to a mineral of the tetragonal or hexagonal systems, then its perfect cleavage planes necessarily correspond to the basis, and both the chief and optic axes are at right angles to the lamina. The ray of light consequently is neither doubly refracted nor polarized in any position of the lamina, and of course is not reflected from the second mirror. If, on the contrary, the mineral belongs to the rhombic or clinohedric systems, then its cleavage planes in general correspond either to the basis or to one of the two vertical chief sections. Hence the two optical axes lie either in the plane of the lamina or in some other plane at right angles or inclined to this plane, but neither of these axes will be vertical to the lamina. Hence the polarized light in passing through the lamina is necessarily doubly refracted, and also depolarized and consequently reflected from the second or testing mirror with four maxima and four minima of intensity. This test is very important for distinguishing among minerals that like mica possess a highly perfect cleavage, the optically monoaxial from the binaxial species, and also enables us to determine the crystal-system to which they belong.

Another beautiful phenomenon of polarized light, in like manner connected with the crystalline structure of minerals, is the coloured rings which laminæ of the doubly-refracting species, when of a proper thickness, exhibit in certain positions. According to the undulatory theory, these rings arise from the interference of the waves of the two rays O and E; and are easily seen in the above apparatus by interposing a thin plate of gypsum or mica between the two mirrors. They may also be employed to distinguish the monoaxial from the binaxial crystals. Thus when the interposed plate belongs to a monoaxial mineral, there is seen in the second mirror a system of circular concentric coloured rings intersected by a black cross. (Fig. 101.) If, on the other hand, the mineral is binaxial, one or two systems of elliptical coloured rings appear, each intersected by a black stripe. (Fig. 102.) In certain cases this stripe is curved, or the two systems of rings unite in a lemniscoidal form. (Fig. 103.) When the planes of polarization are pa-

Fig 101.

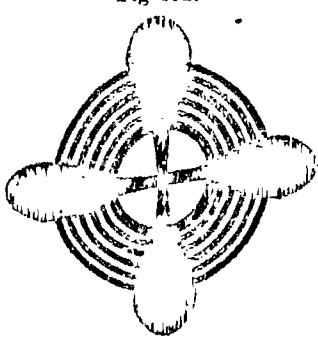


Fig. 102.

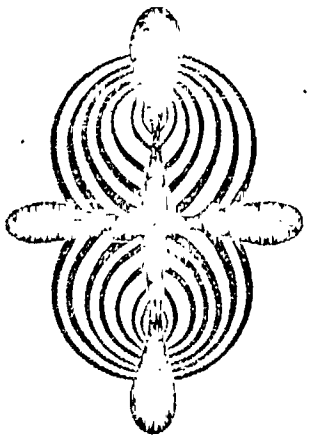
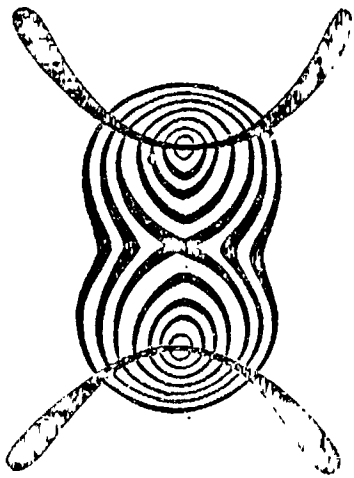


Fig. 103.



rallel, the black cross and stripe appear white (fig. 104), showing that in this direction the crystals act like singly-refracting minerals. Quartz again, in close relation to its tetartohedric system of crystallization, exhibits a circular polarization of splendid prismatic colours, which on turning the plate change in each point in the order of the spectrum, from red to yellow, green, and blue. In order to produce these changes, however, in some specimens, the plate must be turned to the right, in others to the left, showing a difference in their crystalline structure. But these singularly beautiful phenomena, though intimately related to the structure of minerals, have perhaps detained us too long, as the first method is the simplest and most generally applicable test.

Fig. 104.

Pleochroism.—Closely connected with double refraction is that property of transparent minerals which Haidinger names Pleochroism (many-coloured), in consequence of which they exhibit distinct colours when viewed by transmitted light in different directions. Crystals of the tesseral system do not show this property, whilst in those of the other systems it appears in more or less perfection; and in the tetragonal and hexagonal minerals as Dichroism (two colours), in the rhombic and clinohedric systems as Trichroism (three colours). In

the former or dichromatic crystals, the colours are seen in directions parallel and at right angles to the chief axes; in the trichromatic, the rhombic crystals show them at right angles to the three axes; and in the clinohedric system, they also are partly determined by three lines at right angles to each other. In most cases these changes of colour are not very decided, and appear rather as different tints or shades of one colour than as wholly diverse. The most remarkable of dichromatic minerals are the magnesian mica from Vesuvius, the tourmaline and pennine; of trichromatic, the iolite, the andalusite from Brazil, the diaspore from Schemnitz, and the axinite.

Some crystalline minerals exhibit a very lively play or change of colours from reflected light in certain directions. It is well seen in many various hues on the brachydiagonal cleavage planes of Labrador felspar; and, according to the microscopic observations of Sir D. Brewster, is produced in this case from a multitude of very thin quadrangular pores, interposed in the mineral like minute parallel laminæ. On the macrodiagonal cleavage planes of the hypersthene it appears copper-red, and in this case, Scheerer states, is occasioned by numerous small brown or black laminæ of some foreign substance, interposed in a parallel position between the planes of the hypersthene. The chatoyant or changing colours of the sun-stone are shown by the same author to arise from scales of iron-glance similarly interposed. The play of colour in the noble opal seems, according to Brewster's observations, to be produced very nearly in the same manner with that in the labradorite. He has shown that in its mass there are numerous layers of microscopic pores lying in three directions, and that the difference of colour depends on the size of these pores. A similar opalescence is seen in certain minerals when cut in particular forms. In the sapphire, cut hemispherically over the chief axis, it appears like a star with six rays; in certain varieties of chrysoberyl and adularia it has a bluish tint; and is also very remarkable in the cat's-eye variety of quartz. Iridescence often arises from very fine fissures, producing semicircular arches of prismatic tints, which, like the colours of thin plates in general, are referred to the interference of light.

Lustre and Colour.

The two principal phenomena in the mineral kingdom produced by reflected light are lustre and colour. Though, like transparency, these properties admit of no precise or mathematical determination, they are yet of considerable value in mineralogy. One highly-important distinction founded on them is into minerals of metallic and non-metallic aspect or character. This distinction can hardly be described in words, and the student will best learn to dis-

tinguish metallic colours and lustre from non-metallic by observing them in nature. Transparency and opacity nearly coincide with this division, the metallic minerals being almost constantly opaque; the non-metallic more or less transparent. Minerals which are perfectly opaque, and show metallic colour and lustre, are said to be metallic; those with only two of these three properties are semi-metallic or metalloid; and those with the opposite properties non-metallic. The distinction of the first and last is readily observable even in a small portion of a mineral, and is of great value both for the distinction and classification of the species.

Lustre in minerals has reference to the intensity and quality of the reflected light, considered as distinct from colour. Several degrees in intensity have been named. (1.) *Splendent*, when a mineral reflects light so perfectly as to be visible at a great distance, and lively, well defined images are formed in its faces, as seen in galena, rock crystal, or calc-spar. (2.) *Shining*, when the reflected light is weak, and only forms indistinct and cloudy images, as seen in heavy spar. (3.) *Glistening*, when the reflected light is so feeble as not to be observable at a greater distance than arm's length, and the surface can no longer form an image. These two varieties are very common in many minerals. (4.) *Glimmering*, when the mineral held near the eye in full clear day-light presents only a number of small shining points, as seen in red hematite, granular limestone, and other microcrystalline aggregates. When, as in chalk, the lustre is so feeble as to be indiscernible, it is said to be *dull*.

In regard to the kind or quality of the lustre, the following varieties are distinguished. (1.) The *metallic*, as seen in much perfection in native metals and their compounds with sulphur, and imperfectly in glance coal. (2.) *Adamantine*, found in beautiful perfection in the diamond, and in some varieties of ruby silver, blende, and carbonate of lead; and passing into the metallic in some opaque minerals, as the dark varieties of the red silver ore and zinc blende. (3.) *Vitreous* or glassy, as seen in rock crystal or common glass, or inclining to adamantine in flint glass. (4.) *Resinous*, when the body appears as if smeared with oil, as in pitch-stone and garnet. (5.) *Pearly*, like that of mother-of-pearl, seen in stilbite, gypsum, mica, and generally on very perfect cleavage planes. On bronzite it becomes metallic. (6.) *Silky*, the glimmering lustre seen on fine fibrous aggregates like amianthus.

Colour.—Minerals seen either by reflected or transmited light present considerable diversity of colour. This property, however, is not in all cases of equal value as a character, as the following distinctions will show. Thus some minerals are naturally coloured, or idiochro-

matic, showing, in all modes of their occurrence, a very determinate colour, which may therefore be regarded as essential to them, and forms a characteristic mark of the species. This class includes the metals, pyrites, blendes, with many metallic oxides and salts. A second class of minerals are colourless or achromatic, their purest forms being white or clear like water, with no tinge of colour, as ice, calc-spar, quartz, adularia, and many silicates. But many varieties of these minerals are occasionally coloured or allochromatic, accidentally tinged sometimes from the chemical or mechanical admixture of some colouring substance, as a metallic oxide, carbon, or particles of coloured minerals; at other times from the substitution of a coloured for an uncoloured isomorphous element. The colours of these minerals may therefore vary indefinitely, and can never characterise the species, but only its varieties. Thus, quartz, calc-spar, fluor spar, gypsum, and felspar are often coloured accidentally by pigments mechanically mixed; and hornblende, augite, garnet, and other colourless silicates acquire green, brown, red, or black tints from the introduction of isomorphic colouring elements.

Werner, who bestowed much attention on this portion of mineralogy, distinguished eight principal colours,—white, grey, black, blue, green, yellow, red, and brown,—each with several varieties or shades arising from intermixture with the other colours. He also divided them into metallic and non-metallic, as follows.

METALLIC COLOURS.

1. *White.*—(1.) Silver-white is yellowish-white, as in arsenical pyrites and native silver. (2.) Tin-white is milk-white; native antimony.

2. *Grey.*—(1.) Lead-grey is bluish-grey; galena or lead-glance. (2.) Steel-grey is dark ash-grey; native platina.

3. *Black.*—(1.) Iron-black is greyish-black; black or magnetic iron-ore.

4. *Yellow.*—(1.) Brass-yellow is sulphur-yellow; copper pyrites. (2.) Bronze-yellow is brass-yellow mixed with steel-grey, and a minute portion of reddish-brown; iron pyrites. (3.) Gold-yellow is lemon-yellow; native gold.

5. *Red.*—(1.) Copper-red is flesh-red; native copper and copper nickel.

NON-METALLIC COLOURS.

1. *White.*—(1.) Snow-white is the purest colour, and agrees with that of new-fallen snow. Examples occur in Carrara marble and common quartz. (2.) Reddish-white is white with a slight intermixture of red and grey; heavy-spar. (3.) Yellowish-white, white

with very little lemon-yellow and ash-grey; chalk. (4.) Greyish-white is white with a little ash-grey; quartz. (5.) Greenish-white is white with a very little emerald-green and ash-grey; amianthus. (6.) Milk-white is snow-white with a little Berlin blue and ash-grey, or the colour of skimmed milk; calcedony.

2. *Grey.*—(1.) Bluish-grey is ash-grey with a little blue; limestone. (2.) Pearl-grey is pale bluish-grey with a little red; porcelain jasper, and rarely quartz. (3.) Smoke-grey, or brownish-grey, is dark bluish-grey with a little brown, like dense smoke; dark varieties of flint. (4.) Greenish-grey is ash-grey with a little emerald-green, and has sometimes a faint trace of yellow; clay-slate and whet-slate. (5.) Yellowish-grey is ash-grey with lemon-yellow and a trace of brown; calcedony. (6.) Ash-grey, the characteristic colour, is a mixture of black and white; wood-ashes, zoisite, zircon, and slate-clay.

3. *Black.*—(1.) Greyish-black is velvet-black with ash-grey; basalt, lydian stone, and lucullite. (2.) Velvet-black, the characteristic or purest black colour; obsidian and schorl. (3.) Pitch-black, or brownish-black, is black with a little yellowish-brown; cobalt ochre, bituminous coal, and some varieties of mica. (4.) Greenish-black, or raven black, is black with a little greenish-grey; hornblende. (5.) Bluish-black is black with a little blue; reniform cobalt ochre from Saalfeld, fluor spar.

4. *Blue.*—(1.) Blackish-blue is blue with much black, and a trace of red; dark varieties of blue copper. (2.) Azure-blue is blue with a little red; bright varieties of blue copper and lapislazuli. (3.) Violet-blue is blue with much red, and very little black; amethyst and octahedral fluor spar. (4.) Lavender-blue is pale violet-blue with much grey; lithomarge and porcelain jasper. (5.) Plum-blue is blue with more red than in violet-blue, and a small portion of brown and black; spinel and octahedral fluor spar. (6.) Berlin-blue is the purest or characteristic colour; sapphire, rock-salt, cyanite. (7.) Smalt-blue is blue with much white, and a trace of green; pale-coloured smalt, gypsum. (8.) Duck-blue is blue with much green, and a little black; ceylanite, talc, and corundum. (9.) Indigo-blue is a deep blue with a considerable portion of black, and a little green; earthy blue iron or vivianite. (10.) Skye-blue, the mountain-blue of painters, is a pale blue with green, and a little white; lenticular copper, some varieties of fluor spar, and of blue spar.

5. *Green.*—(1.) Verdigris-green is green with much Berlin-blue and a little white; amazon stone, and prismatic liriconite. (2.) Celandine-green is verdigris-green with ash-grey; green earth, Siberian and Brazilian beryl. (3.) Mountain-green is green with much blue,

and a little yellowish-grey; beryl, aqua-marine topaz. (4.) Leek-green is emerald-green with bluish-grey and a little brown; common actynolite and prase. (5.) Emerald-green is the characteristic or pure green; emerald, and some varieties of green malachite. (6.) Apple-green is green with a little greyish-white; chrysoprase. (7.) Grass-green is green with a little lemon-yellow; uranite, smaragdite. (8.) Blackish-green; augite, and precious serpentine. (9.) Pistachio-green, the sap-green of painters, is emerald-green with yellow and a small portion of brown; chrysolite and epidote. (10.) Asparagus-green is emerald-green with yellow and a little brown; the apatite or asparagus stone, from Spain and Salzburg. (11.) Olive-green is grass-green with much brown and a little grey; garnet, pitch-stone, and olivine. (12.) Oil-green is emerald-green with yellow, brown, and grey; or pistachio-green with much yellow and light ash-grey; olive-oil, yellow-blende, beryl. (13.) Siskin-green is emerald-green with much lemon-yellow and a little white; uran mica and some varieties of pyromorphite.

6. *Yellow.*—(1.) Sulphur-yellow is lemon-yellow with much emerald-green and white; native sulphur. (2.) Straw-yellow is sulphur-yellow with much greyish-white; some varieties of schorlite and carpholite. (3.) Wax-yellow is lemon-yellow with reddish-brown and a little ash-grey; opal and yellow lead-spar. (4.) Honey-yellow is sulphur-yellow with chestnut-brown; dark varieties of honey, fluor spar and beryl. (5.) Lemon-yellow is the pure or characteristic colour; rind of ripe melons, yellow orpiment. (6.) Ochre-yellow is lemon-yellow with a considerable quantity of light chestnut-brown; yellow-earth and jasper. (7.) Wine-yellow is lemon-yellow with a small portion of red and greyish-white; Saxon and Brazilian topaz, and octahedral fluor spar. (8.) Cream-yellow, or Isabella-yellow, contains more red and grey than the wine-yellow, and also a little brown; bole from Strigau and compact limestone. (9.) Orange-yellow is lemon-yellow with carmine red; rind of the ripe orange, uran-ochre, and some varieties of molybdate of lead.

7. *Red.*—(1.) Aurora, or morning-red, is carmine-red with much lemon-yellow; red orpiment. (2.) Hyacinth-red is carmine-red with lemon-yellow, and a minute portion of brown; hyacinth and dodecahedral garnet. (3.) Tile-red is hyacinth red with greyish-white; fresh-burned porcelain jasper, and some varieties of foliated zeolite. (4.) Scarlet-red is carmine-red with a very little lemon-yellow; light red cinnabar from Wolfstein. (5.) Blood-red is scarlet-red, with a small portion of black; blood, pyrope. (6.) Flesh-red is blood-red with greyish-white; felspar and heavy spar. (7.) Carmine-red is the characteristic colour; carmine, spinel, particularly in thin splint-

ers. (8.) Cochineal-red is red with bluish-grey; cinnabar and certain garnets. (9.) Crimson-red is red with a considerable portion of blue; oriental ruby and cobalt bloom. (10.) Columbine-red is red with more blue, and, what is characteristic for this colour, a little black; precious garnet. (11.) Rose-red is cochineal-red with white; red manganese and rose-quartz. (12.) Peach-blossom-red is crimson-red with white; blossoms of the peach, red cobalt-ochre. (13.) Cherry-red is crimson-red with a considerable portion of brownish-black; spinel, red antimony, and precious garnet. (14.) Brownish-red is blood-red with brown; reddle, a ferruginous clay used in drawing, and columnar clay ironstone.

8. *Brown.*—(1.) Reddish-brown is chestnut-brown mixed with a little red and yellow; brown-blende from the Hartz, and pyramidal zircon. (2.) Clove-brown is brown with cochineal-red and a little black; the clove, rock-crystal, and axinite. (3.) Hair-brown is clove-brown with ash-grey; wood-opal and brown iron-ore. (4.) Broccoli-brown is brown with much blue and a small portion of green and red; zircon. (5.) Chestnut-brown is the characteristic or pure brown colour; Egyptian jasper. (6.) Yellowish-brown is brown with a considerable portion of lemon-yellow; iron-flint and jasper. (7.) Pinchbeck-brown is yellowish-brown with metallic or semi-metallic lustre; or rather the colour of tarnished pinchbeck; mica. (8.) Wood-brown is yellowish-brown with much pale ash-grey; mountain wood and bituminous wood. (9.) Liver-brown is brown with olive green and ash-grey; boiled liver, common jasper. (10.) Blackish-brown is brown with black; mineral pitch from Neufchatel, and moor coal.

The accidentally-coloured minerals sometimes present two or more colours or tints on different parts, even of a single crystal; very remarkable examples occurring in fluor spar, apatite, sapphire, amethyst, tourmaline, and disthene. This appearance is still more common in compound minerals, especially the minute crystalline aggregates, on which the colours are variously arranged in points, streaks, clouds, veins, stripes, bands, or in brecciated and ruin-like combinations. The pleochroism already noticed seems a distinct phenomenon. Some minerals again change their colour in the course of time from exposure to the light, the air, or damp. Sometimes merely the surface is affected or *tarnished*, and then appears covered as with a thin film, producing in some minerals, as silver, arsenic, bismuth, only one colour; in others, as copper pyrites, iron-glance, stibine, or antimony-glance, and common coal, various or iridescent hues. Occasionally, the change pervades the whole mineral, the colour sometimes becoming paler, or disappearing as in chrysoprase and rose-quartz; at other

times darker, as in brown spar, sparry iron, and manganese spar. In a few minerals a complete change of colour takes place, as in the chlorophaeite of the Western Isles, which, on exposure for a few hours, passes from a transparent yellow-green to black. These mutations seem generally connected with some chemical change. It is, however, remarkable that the tarnished colours sometimes only appear on certain faces of a crystal belonging to a peculiar form. Thus a crystal of copper pyrites in the Berlin Museum, like fig. 38 above, has the face P′ free from tarnish, the faces *b* and *c* close to P′ are dark blue, the remainder of *c* first violet, and then close to P gold yellow. Von Kobell has produced a very beautiful tarnish on copper pyrites through galvanic influence, which may partly explain its occurrence in nature.

Phosphorescence, Electricity, Magnetism, and Thermal Relations of Minerals.

Phosphorescence is the property possessed by particular minerals of producing light in certain circumstances different from combustion or ignition. Thus some minerals appear luminous when taken into the dark after being for a time exposed to the sun's rays, or even only to the ordinary day-light. Many diamonds and calcined barytes exhibit this property in a very remarkable degree; less so, strontianite, arragonite, calc-spar, and chalk; and in a still inferior degree rock-salt, fibrous gypsum, and fluor spar. In quartz and the greater number of the silicates it is wholly wanting. Many minerals, including the greater part of those thus rendered phosphorescent by the influence of the sun or insolation, also acquire it through heat. The temperature required is very different. Thus some topazes, diamonds, and varieties of fluor spar become luminous by the heat of the hand; other varieties of fluor spar and the phosphorite require a temperature near that of boiling water; whilst calc-spar and many silicates are only phosphorescent at from 400° to 700° Fahr. Electricity produces it in some minerals, as in green fluor spar and calcined barytes. In others it is excited when they are struck, rubbed, split, or broken; as many varieties of zinc blende and dolomite when scratched with a quill; pieces of quartz when rubbed on each other; and plates of mica when suddenly separated. Though interesting, these properties are of little value in mineralogy.

Friction, pressure, and heat also excite *electricity* in minerals, though in such of them as are conductors it is only perceptible when they are isolated. To observe this property delicate electroscopes are required, like that of Hauy, formed of a light needle, terminating at both ends in small balls, and suspended horizontally on a steel pivot

by an agate cup. It can be negatively electrified by touching it with a stick of sealing-wax, excited by rubbing, or positively when the wax is only brought so near as to attract the needle. When the instrument is in this state, the mineral, if also rendered electric by heat or friction, will attract or repel the needle according as it has acquired electricity of an opposite or similar kind; but if the mineral is not electric, it will attract the needle in both conditions alike. Most precious stones become electrical from friction, and are either positive or negative according as their surface is smooth or rough. Pressure even between the fingers will excite distinct positive electricity in pieces of transparent double-refracting calc-spar. Topaz, arragonite, fluor spar, carbonate of lead, quartz, and other minerals show this property, but in a much smaller degree.

Heat or change of temperature excites electricity in many crystals, as in those of scolezite, axinite, prehnite, boracite, tourmaline, calamine, topaz, titanite, calc-spar, beryl, barytes, fluor spar, diamond, garnet, and others; which are hence said to be thermo or pyro-electric. In some of these the two electricities appear in opposite parts of the crystal, and these are said to acquire polar pyro-electricity, and the points in which they exhibit this property are named their electric poles.

It is remarkable that each pole is alternately positive and negative, —the one when the mineral is heating, the other when it is cooling. G. Rose and Reiss name the poles that become positive during an increase of temperature analogue; those that become negative in the same condition antilogue poles. This distinction will be better shown in this table.

Temperature		Electricity
+ or rising	produces in analogue poles	+ or vitreous.
— or falling		— or resinous.
+ or rising	in antilogue poles	— or resinous.
— or falling		+ or vitreous.

As already noticed, many polar electric minerals are also remarkable for their hemimorphic crystal forms, seeming to establish some causal connexion between these two phenomena. The number and distribution of the poles also varies. In many monoaxial minerals, as tourmaline, calamine, scolezite, there are only two poles, one at each end of the chief axis; whereas boracite has eight poles corresponding to the angles of the cube. In prehnite and topaz again, Rose and Reiss found two antilogue poles on the obtuse lateral edges of the prism ∞P, and one analogue pole corresponding to the macrodiagonal chief section, or in the middle of the diagonal joining the obtuse edges.

Magnetism, or the power to act on the magnetic needle, is found in only a few minerals, of which it is very characteristic. It seems generally to depend on the presence of iron, though perhaps this is not always the case. It is either simple, attracting both poles of the needle, or polar, when by one part it attracts, by another repels the same pole. Some magnetic iron ores, or natural magnets, possess polar magnetism; whilst the common varieties, meteoric iron, magnetic pyrites, precious garnet, and other minerals containing much protoxide of iron, are simply magnetic. Most minerals are only attracted by the magnet, but are not able themselves to attract iron.

M. Senarmont has recently affirmed that crystals, in conducting heat, act in a manner analogous to the phenomena they exhibit in the transmission of light, though the laws are not in all cases identical. In tesseral crystals heat is conducted equally in every direction, and the isothermal planes are spherical and concentric. Tetragonal and hexagonal crystals conduct alike in all directions perpendicular to the chief axis, and the isothermal planes are concentric ellipsoids of revolution. In the other three systems the conductibility varies in three directions, which in some cases have a fixed position relative to the axes, in others this has not been discovered; and the isothermal surfaces are ellipsoidal figures, but not of revolution.*

* Comptes Rendus, Nov. 1847, p. 708.

CHAPTER III.

CHEMICAL PROPERTIES OF MINERALS.

A perfect mineral species, as above stated, should possess not only a regular external form, but also a definite chemical composition. The consideration, therefore, of the chemical nature of minerals, of the elements that enter into their composition, of the manner in which these combine, and the variations in proportion which they may undergo without destroying that identity essential to the unity of the species, forms an important branch of mineralogical science. The methods of detecting the different elements in minerals, and the characters which are thus furnished for the discrimination of species, are also of much value. This is especially true of the metallic ores and some other substances, sought not as objects of curiosity, but for their economic qualities. The elementary constituents of the mineral kingdom can, indeed, only be determined quantitatively by precise and often difficult chemical analysis, but a qualitative investigation can in general be more easily accomplished by a few simple tests and reagents, which point out the true nature of the mineral, and render further chemical examination unnecessary.

Composition of Minerals.—A very general review of the elementary constituents of minerals is sufficient for our purpose, and a more extended description must be sought in books on chemistry. At present sixty (or sixty-two) elements, or substances which have not been decomposed, are known. Some of the most recently discovered of these, as the metals, didymium, erbium, terbium, niobium, pelopium, the ruthenium of Claus, and the new earth found by Svanberg in eudialite—are so little known or their elementary character so doubtful, that it is unnecessary to consider them further. The remainder are divided into metallic and non-metallic, a distinction of importance in mineralogy, though not always to be carried out with precision. The non-metallic elements are gaseous, fluid, or solid bodies, the latter rarely of semimetallic aspect, and are bad conductors of heat and electricity. Some are commonly gaseous,—oxygen, hydrogen, nitrogen, chlorine, and fluorine,—one fluid, bromine, the others solid—carbon, phosphorus, sulphur, boron, selenium, and iodine. The metallic elements are, except mercury, solid at usual temperatures, have generally a metallic aspect, and are good conductors of heat and electricity. They are divided into light and heavy metals, the former with a specific gravity under 5, and a great affinity for oxygen, and again distinguished as either alkali-metals, potassium

(or kalium), sodium (or natrium), lithium, barium, strontium, and calcium ;—or earth-metals, magnesium, lanthanium, yttrium, glucinum, aluminium, zirconium, silicium. The heavy metals with a specific gravity above 5, are divided into noble, which can be reduced by heat alone,—and ignoble, whose affinity for oxygen renders them irreducible without other agents. Some of the latter are brittle and difficultly fusible,—thorium, titanium, tantalium (columbium), tungsten (wolframium), molybdenum, vanadium, chromium, uranium, manganese, and cerium ;—others are brittle and easily fusible or volatile—arsenic, antimony, tellurium, and bismuth ;—and others malleable—zinc, cadmium, tin, lead, iron, cobalt, nickel, and copper. The noble metals are, quicksilver, silver, gold, platinum, palladium, rhodium, iridium, and osmium.

All the chemical combinations observed in the mineral kingdom follow the law of definite proportions. Two substances may, indeed, unite in different quantities, but the proportion of the one to the other is either uniform, or is some multiple or submultiple of the former by a number seldom very large. As the same law prevails throughout the whole range of elements,—by assuming any one, usually hydrogen or oxygen, as unity or 1, and determining from experiment the simple proportion in which the others combine with this, a series of numbers is obtained which expresses the proportions in which all these elements combine with each other. These numbers, therefore, mark the combining proportions or equivalents, as they are named, of the elements. They are also named atomic weights, on the supposition that matter consists of definite atoms, and that its combinations consist of one atom (or sometimes two atoms) of one substance, with one, two, three, or more atoms of another. This theory is not free from difficulties, but the language is often convenient, and may occasionally be used. To designate the different elements, chemists now generally employ the first letter or letters of their Latin names. These signs also indicate one atom or equivalent of the element. Thus, O means oxygen in the proportion of one atom; H, hydrogen in the same proportion ; N, an atom of nitrogen ; Na, an equivalent proportion of natrium or sodium. These signs and the equivalent weights are given in the following table, in one column of which hydrogen is taken as unity, in the other oxygen. The numbers in the first column are those given by Naumann, chiefly after L. Gmelin, those in the column under oxygen are from Rammelsberg. The elements are arranged according to Berzelius, beginning with the most electropositive and ending with the most electronegative, and therefore generally so that their oxides shall always be less and less electropositive. The true place of some elements is, however, still uncertain, and the order thus far is only *conventional.*

TABLE I.—Elements arranged in Electro-Chemical order.

Name.	Sign.	Atomic Weight. H=1	Atomic Weight. O = 100.	Name.	Sign.	Atomic Weight. H=1	Atomic Weight. O = 100.
Potassium ...	K	39·2	488·856	Rhodium	Rh	52	651·400
Sodium	Na	23·2	290·897	Ruthenium ...	Ru	...	..
Lithium	Li	6·4	80·375	Iridium	Ir	99	1233·260
Ammonium...	NH^3	17	...	Platinum ...	Pt	99	1233·260
Baryum	Ba	68·6	856·880	Osmium	Os	99	1244·210
Strontium ...	Sr	44	547·285	Gold.....	Au	198	*2458·83
Calcium	Ca	20	251·489	Hydrogen ...	H	1	*12·479
Magnesium ...	Mg	12	151·33	Silicium	Si	15	187·5 †
Yttrium	Y	32	402·514			22·2	277·312‡
Glucinum ...	G	4·7	58·084	Carbon.....	C	6	75·00
Aluminium ...	Al	13·7	*342·334	Boron	B	10·8	135·983
Zirconium ...	Zr	22·4	*840·402	Titanium	Ti	24	303·686
Thorium	Th	59·6	744·900	Tantalium ...	Ta	185	1153·715
Cerium.....	Ce	46	574·718?	Niobium	Nb	..	...
Lanthanium	La	36 ?	...	Pelopium.....	Pp	..	..
Didymium ...	D	...	...	Wolframium	W	96	1183·200
Uranium	U	60	742·84	Molybdenum	Mo	48	598·525
Manganese ...	Mn	28	345·890	Vanadium ...	V	68·6	855·840
Iron	Fe	28	350·527	Chromium ..	Cr	26·3	328·39
Nickel	Ni	29·5	369·675	Tellurium ...	Te	64	802·121
Cobalt	Co	29·5	368·991	Antimony ...	Sb	129	1612·904
Zinc	Zn	32·2	406·59	Arsenic	As	75	*940·084
Cadmium.....	Cd	56	696·767	Phosphorus ...	P	31·4	*392·286
Tin	Sn	59	735·294	Nitrogen	N	14	*175·06
Lead	Pb	104	1294·498	Selenium	Se	40	494·582
Bismuth	Bi	213	*2660·76	Sulphur	S	16	200·75
Copper.....	Cu	31·7	395·695	Oxygen	O	8	100
Mercury	Hg	100	1250·6	Iodine	I	126	*1586·00
Silver	Ag	108	1349·66	Bromine	Br	78·4	*999·62
Palladium ...	Pd	53·3	665·840	Chlorine	Cl	36	*443·28
				Fluorine	F	18·7	*233·800

In the above list Berzelius includes ammonium, usually considered a compound body, and omits the two new metals, erbium and terbium.

A few minerals consist of one element in its pure state, or with only inconsiderable and accidental admixtures. Thus the diamond and graphite are nearly pure carbon; quartz pure silica; sulphur and the native metals the corresponding elements. Most frequently, however, minerals consist of two or more elements combined in accordance with those laws which chemists have found to prevail in inorganic compounds, as distinguished from the organic. The most important

* Double atoms.
† L. Gmelin, who considers silica as composed of one atom base and two oxygen.
‡ Berzelius.

of these is that the combinations are binary, that is, that the elements unite in pairs, which may, however, again unite either with another compound of two, or with a single element. Hence chemists distinguish combinations of the first, second, third order, and so on; the combination of two elements being of the first order; the combination of two combinations of the first order being of the second, and the combination of two of the second being of the third. In the mineral kingdom combinations of a higher order are very rare, and inorganic compounds are generally distinguished from organic by their greater simplicity. Combinations of one order with another are not unfrequent, as of water belonging to the first with substances belonging to the second or third order. This law of binary combination seems connected with the electric character of the elements by which one is electropositive or electronegative to the others, or so that the one is attracted to the negative, the other to the positive pole. This character is only relative, and in Berzelius' arrangement each element in the series is electropositive to all that precede, and electronegative to all that follow.

The following principles are observed in designating the combinations of these elementary substances. For those of the first order the signs of the two components are conjoined, and the number of atoms or equivalents of each expressed by a number following the sign like an algebraic exponent. Thus, SO, SO^2, SO^3 are the combinations of one atom sulphur with one, two, and three atoms of oxygen; FeS, FeS^2, of one atom iron with one or two sulphur. But as combinations with oxygen and sulphur are very numerous in the mineral kingdom, Berzelius, to whom science is indebted for this system of signs, marks the atoms of oxygen by dots over the sign of the other element, and those of sulphur by an accent; the above compounds being then wrote thus, $\dot{S}$, $\ddot{S}$, $\dot{S}$, and Fe', Fe''. In some cases two atoms of a base combine with three or five of oxygen or sulphur, as Al^2O^3, Fe^2S^3. In such cases Berzelius marks the double atom by a line drawn through the sign of the single atom, and this system has been almost universally followed in foreign works. In this country, however, such types are not to be procured, and we have been obliged to adopt the substitute proposed by Mr Dana, of using the thick black letter to mark the double atoms; thus, $\ddot{\mathbf{A}}\mathbf{l}$ is two atoms aluminium with three of oxygen or alumina; $\dot{\mathbf{C}}\mathbf{u}$, two of copper with one of oxygen or oxide of copper. Where a number is prefixed to the sign like a co-efficient in algebra, it includes both elements of the combination; thus, $\dot{H}$ is one atom water, $_2\dot{H}$ two; $\dot{C}a\ddot{C}$ is one atom carbonate of lime, $_2\dot{C}a\ddot{C}$ two atoms, including of course two of calcium, two of carbon, and six of oxygen.

The most common and important binary compounds are those with oxygen, which have been variously distinguished and divided. The more electronegative are named acids, which are often soluble in water, and then render blue vegetable colours red. The more electropositive are named oxides or bases, and show great affinity or attractive power for the former. The most powerful are the alkaline bases, which are colourless, and soluble in water; less powerful are the earths, also colourless, but insoluble in water.

The table opposite contains the more common compounds, with their signs, atomic numbers, and amount of oxygen in 100 parts.

Similar to the compounds of oxygen are those with sulphur, usually named sulphurets, and considered analogous to the oxidized bases. A few of more electronegative character, resembling acids, have been distinguished as sulphides; as the compounds, with antimony, SbS^3; with arsenic, AsS^3; and with tin, SnS^2.

Some other compounds of the first order have been named Haloid salts by Berzelius, and consist of certain electronegative elements, combined with electropositive ones, as bases. The most frequent bodies of the former class in the mineral kingdom are chlorine, fluorine, iodine, and bromine; and common salt, fluor spar, iodide and bromide of silver, are examples of the compounds. They form exceptions to the common species of salts, which are generally combinations of the second order; yet it would be improper to exclude them from this class, with which they closely agree in physical properties, and of which one of them, common salt, has been the true representative in all nations.

Many combinations of the first order occur as independent species in the mineral kingdom, especially those with oxygen and sulphur. Thus the most abundant of all minerals, quartz, is an oxide, and corundum is of similar nature. Many oxides of the heavy metals, as of iron, tin, copper, and antimony; and some super-oxides, as of lead and manganese (pyrolusite), are very common. Compounds with sulphur also abound, and either as sulphides, with the character of acids, like realgar, orpiment, and antimony-glance; or as sulphurets resembling bases, like galena, silver-glance, and iron pyrites. Less frequent are haloid salts, with chlorine and fluorine, as common salt and fluor spar; and still rarer those with iodine and bromine. On the other hand, metallic alloys, or combinations of electronegative with electropositive metals, are far from uncommon, especially those with arsenic, tellurium, or antimony.

Combinations of the second order are still more common in nature; the greater number of minerals being composed of an acid and base, or what Berzelius names in general Amphid salts, dividing them again

TABLE II.—Binary Compounds with Oxygen.

Name.	Sign.	Atomic Weight H=1	Atomic Weight O=100.	Oxyg. in 100 parts.
Alumina	Al	51·4	642·33	46·70
Antimony oxide	Sb	153	1912·904	15·68
Antimonious acid	Sb	161	2012·904	19·89
Antimonic acid	Sb	169	2112·904	23·8
Arsenious acid	As	99	...	...
Arsenic acid	As	115	1440·08	34·72
Baryta	Ba	76·6	956·88	10·45
Bismuth peroxide	Bi	237	2960·76	10·13
Boracic acid	B	34·8	436·20	68·78
Carbonic acid	C	22	275·0	72·73
Cerium protoxide	Ce	54	674·72	14·82
—— peroxide	Ce	116	1449·39	20·70
Chromium oxide	Cr	76·6	956·78	31·35
Chromic acid	Cr	50·3	628·39	47·74
Cobalt protoxide	Co	37·5	468·99	21·32
Copper suboxide (red)	Cu	71·4	891·39	11·12
—— protoxide (black)	Cu	39·7	495·69	20·17
Glucina	G	12·7	158·084	63·26
Iron protoxide	Fe	36	450·527	22·19
—— peroxide (red)	Fe	80	1001·054	29·97
—— proto-peroxide (black)	Fe + Fe	116	1451·581	26·08
Lead protoxide	Pb	112	1394·50	7·17
Lime or Calcia	Ca	28	351·489	28·45
Lithia	Li	14·4	180·37	55·45
Magnesia	Mg	20	251·33	39.79

Name.	Sign.	Atomic Weight H=1	Atomic Weight O=100.	Oxyg. in 100 parts.
Manganese protoxide	Mn	36	445·89	22·43
—— peroxide	Mn	80	991·77	30·25
—— protoperox. (red)	Mn + Mn	116	1437·66	26·34
Molybdic acid	Mo	72	898·52	33·39
Nickel protoxide	Ni	37·5	469·68	21·29
Nitric acid	N	54	675·06	74·07
Phosphoric acid	P or P	71·4	892·28	56·04
Potassa	K	47·2	588·856	16·98
Silica (Gmelin)	Si	31	387·5	51·61
—— (Berzelius)	Si	46·2	577·31	51·96
Soda	Na	31·2	390·90	25·58
Strontia	Sr	52	647·29	15·45
Sulphuric acid	S	40	500·75	59·91
Tantalic acid	Ta	209	2607·43	11·51
Thorina	Th	67·6	844·90	13·34
Tin peroxide	Sn	75	935·29	21·38
Titanic acid	Ti	40	503·68	39·71
Tungstic acid	W	120	1483·00	20·23
Uranium protoxide	U	68	842·84	13·33
—— peroxide	U	144	1785.68	16·66
Vanadic acid	V	92	1155·84	26·19
Water	H	9	112·48	88·89
Yttria	Y	40	502·51	19·90
Zinc oxide	Zn	40·2	506·59	19·74
Zirconia	Zr	30·4	...	26·32

into oxygen-salts, sulphur-salts, tellurium-salts, and so on. By far the greater number are oxygen-salts, distinguished by giving to the acid the termination *ate;* thus sulphate of lead, silicate of lime, and in like manner, numerous carbonates, phosphates, arseniates, aluminates; and in less number, molybdenates, titanates, tantalates, and vanadianates. The sulphur-salts, two metals combined with sulphur, and again combined with each other, are next in number, and perform a most important part in the mineral kingdom. Less common are salts of selenium and tellurium; whilst those of arsenic are not unfrequently united in an analogous manner with the sulphurets. The latter more rarely unite with a metallic oxide, as in antimony-blende. The hydrates or combinations of an oxide with water are also common, and much resemble the oxygen salts, the water sometimes acting as an electropositive, at other times as an electronegative element.

Combinations of the third order are likewise common, especially the double salts, or the union of two salts into a new body. The two salts are of course in opposite electric conditions, and are either both amphid salts, those of two oxygen-salts, especially the silicates, being remarkably abundant, as brown spar, leucite, orthoclase, augite, garnet; less so two sulphur-salts, as in bournonite; or rarely both haloid salts, as cryolite; or more frequently an amphid and haloid salt, as in apatite, pyromorphite, and kerate. To the same class belong combinations of an oxygen-salt with water, as gypsum. The combinations of the fourth order in the mineral kingdom are especially those produced by the union of double salts with water, as alum and many hydrous silicates. The chemical formula for these double salts are formed by writing the signs of the two simple salts with the sign of addition between them: thus, $\dot{C}a\ddot{c} + \dot{M}g\ddot{c}$, *i. e.* carbonate of lime and carbonate of magnesia, or brown spar; $\ddot{A}l\ddot{s}^3 + {}^{K}s^3$, or orthoclase; $3NaF + AlF^3$, or cryolite, composed of three compound atoms of fluorine and sodium united to one compound atom consisting of three of fluorine and one of aluminium.

Influence of the Chemical Composition on the External Characters of Minerals.

That the characters of the compound must in some way or other depend on those of its component elements, seems, as a general proposition, to admit of no doubt. Hence it might be supposed possible, from a knowledge of the composition of a mineral, to draw conclusions in reference to its form and other properties; but practically this has not yet been effected, though Mitscherlich and others have made some important discoveries in this most interesting department of mineralogical science. The distinction first pointed out by Beudant between the *élémens minéralisateurs* and *mineralisables*,

or, as it may be translated, the mineralizing and mineralizable, or the forming and formed, elements, as L. Gmelin, who further developed this theory, named them, lies at the foundation of all such inquiries, and, notwithstanding the objections of Berzelius, expresses a very important truth. Certain elements in a compound apparently exert more than an equal share of influence in determining its physical properties. Thus the more important non-metallic elements, as oxygen, sulphur, chlorine, fluorine, are remarkable for the influence they exert on the character of the compound. The sulphurets, for example, have more similarity among themselves than the various compounds of one and the same metal with the non-metallic bodies. Still more generally it would appear that the electronegative element in the compound is the most influential, or exerts the greatest degree of active forming power. Hence in grouping the species the electronegative element should ever be allowed the chief weight. After the non-metallic elements, the brittle, easily fusible metals rank next in power; then the ductile ignoble metals; then the noble metals; then the brittle, difficultly fusible; and last of all the metals of the earths and alkalis.

It is sometimes supposed that each particular substance can crystallize only in one particular form or series of forms. Mitscherlich has, however, shown that this is only partially true, and that sulphur, for instance, which usually crystallizes in the rhombic system, when melted may form monoclinohedric crystals. This property is named *dimorphism*, and has been explained by its discoverer on the principle that the form, and with it the other physical characters of a body, depend not merely on the chemical nature of the atoms, but also on their relative position. Hence the same chemical substance may form two, or even more, distinct bodies or mineral species. Thus carbon in one form is the diamond, in another graphite; carbonate of lime appears as calc spar or arragonite; the bisulphuret of iron as pyrites and marcasite. An example of trimorphism occurs in the titanic acid, forming the three distinct species, anatase, rutile, and brookite. Even the temperature at which a substance crystallizes influences its forms, and so far its composition, as seen in arragonite, Glauber salt, natron and urao, borax, &c.

Still more important is the doctrine of *isomorphism*—also a discovery of Mitscherlich. This term designates the capability shown by two or more simple or compound substances to crystallize in one and the same form; or often in forms which, though not identical, yet approximate very closely, when it has been named homœomorphism. This similarity of form is generally combined with a similarity in other physical properties. Among minerals that crystallize in the tesseral form, isomorphism is of course common, with the distinction

between the holohedric and hemihedric series. Thus many native metals, common salt, fluor spar, galena, spinel, and others, agree in form; so also the boracite, grey copper, and zinc blende. In this system isomorphism is perfect, there being no diversity in the dimensions of the primary form; but for this very reason it is of less interest. It is of more importance among monoaxial crystals, the various series of which are separated from each other by differences in the proportion of the primary form. In these perfect identity is seldom observed, but only very great similarity or homœomorphism.

The more important isomorphic or vicarious substances have been arranged by von Kobell in the following groups:—

I. Simple substances:—
  (1.) Fluorine and chlorine.
  (2.) Sulphur and selenium.
  (3.) Arsenic, antimony, tellurium.
  (4.) Cobalt, iron, nickel.
  (5.) Copper, silver, quicksilver, gold?

II. Combinations with oxygen:—
  (1.) Of the formula $\dot{R}$ (R = the electropositive element, base, or radicle).
    (*a.*) Lime, magnesia, protoxide of iron, protoxide of manganese, oxide of zinc, oxide of nickel, oxide of cobalt, potassa, soda (yttria? cadmium-oxide? cerium-protoxide?).
    (*b.*) Lime, baryta, strontia, lead-oxide.
  (2.) Of the formula $\ddot{R}$.
    (*a.*) Alumina, peroxide of iron, peroxide of manganese, oxide of chromium (bismuth-oxide?).
    (*b.*) Antimony oxide, arsenious acid.
  (3.) Formula $\dot{R}$. Tin-oxide, titanium-oxide.
  (4.) Formula $\dddot{R}$. Phosphoric acid, arsenic acid.
  (5.) Formula $\ddot{R}$.
    (*a.*) Sulphuric acid, selenic acid, chromic acid, manganese acid.
    (*b.*) Tungstic acid, molybdic acid.

III. Combinations with sulphur:—
  (1.) Formula R': sulphuret of iron Fe', and sulphuret of zinc Zn'.
  (2.) Formula R''': sulphuret of antimony Sb''', and sulphuret of arsenic As'''.
  (3.) Formula R': sulphuret of copper Cu', and sulphuret of silver Ag'.

These elements are named vicarious, from the singular property that in chemical compounds they can mutually replace each other in indefinite proportions, and very often without producing any important

change in the form or other connected physical properties. This is especially true of the oxygen salts, in which at one time the basis, at another the acid, is in part replaced by isomorphous constituents. But there are numerous instances among the silicates, where the co-existence and mutual replacement of the isomorphic elements, especially when the oxides of the heavy metals come in the room of the earths and alkalis, exerts a most essential influence on the external aspect of the species, particularly in regard to colour, specific gravity, and transparency. The varieties of hornblende, augite, garnet, epidote, and many other minerals, are remarkable proofs of this influence. The replacement of colourless by coloured matter has often given occasion to the formation of false species, which have had to be again united, the characters by which they were separated being wholly evanescent. This intermixture of isomorphic elements confers many valuable properties on minerals, and to it this department of nature owes much of its variety and beauty. Without the occasional presence of the colouring elements, especially the oxides of iron and manganese, the non-metallic combinations would have exhibited a very monotonous aspect. It is also remarkable that in some silicates the substitution of a certain portion of the metallic oxides for the earthy bases seems to be almost a regular occurrence, whilst in others, as the felspars and zeolites, this rarely happens. The general chemical formula for such compounds is formed by writing R (= radicle or basis) for the whole isomorphic elements; and in special instances to place their signs either one below the other, connected by a bracket, or, as is more convenient, to enclose them in brackets one after the other, separated by a comma. Thus the general sign for the garnet is $\dot{R}^3\,\dot{S}i^2 + \ddot{R}\,\dot{S}i$, which, when all its components are expressed, becomes $\left.\begin{matrix}\dot{Ca}^3\\ \dot{Fe}^3\\ \dot{Mn}^3\end{matrix}\right\}\dot{S}i^2 + \left.\begin{matrix}\ddot{Al}\\ \ddot{Fe}\end{matrix}\right\}\ddot{S}i$; or $(\dot{Ca}^3, \dot{Fe}^3, \dot{Mn}^3)\dot{S}i^2, +(\ddot{Al}, \ddot{Fe})\,\ddot{S}i$, and the mineral forms many varieties as the one or other element predominates.

From an examination of aspasiolite, which is found at Krageroe in Norway in the form and in union with cordierite, M. Scheerer has introduced a new kind of isomorphism, which he names polymerous. He states that in compounds containing magnesia, protoxide of iron, oxide of nickel, and other isomorphous oxides ($\dot{R}$ § (a) above), part of the base may be replaced by water containing three times as much oxygen. Thus $\dot{Mg}^3\ddot{S}i$, $\dot{Mg}^2\ddot{S}i + 3\,\dot{H}$, and $\dot{Mg}\ddot{S}i + 6\,\dot{H}$, are isomorphous compounds, one or two atoms of magnesia with the same number of atoms of oxygen having been replaced by water containing three or six atoms of oxygen. Thus chrysolite and serpentine are isomorphous, the former being represented by the

first formula above, $\dot{M}g^3\ddot{S}i$, and the latter by the second, the general formula being in this case $(\dot{R})^3\ddot{S}i$—silica being taken as containing three atoms of oxygen. On this supposition he has been able to give much simpler formula for many minerals than those formerly in use. But Haidinger shows that aspasiolite is probably a mere pseudomorph or product of decomposition of cordierite. Naumann also observes that this theory requires great accuracy in determining the relative amount of the constituents, and likewise a certain agreement in crystalline form. It is, however, a new hypothesis, for which no proof is given, that three atoms of water have the form of one of magnesia. Scheerer's analysis, too, would be better represented by assuming that four atoms water replaced one of magnesia, and the assumption of even five atoms makes no great distinction. The new formula also are often not more probable than the old; so that, as Rammelsberg remarks, the theory still wants that support in facts which is necessary for its reception.

Chemical Reaction of Minerals.

The object of the chemical examination of minerals is the discovery of those elementary substances of which they consist. This examination is named *quantitative* when not only the nature of the substances but also their relative amount is sought to be determined; and *qualitative* when the nature of the elements is alone desired. Mineralogists, appealing to chemistry chiefly as a discriminative character, are in general content with such an examination as will discover the more important elements, and which can be carried on with a simple apparatus, and small quantities of the substance investigated. The indications thus furnished of the true character of the mineral are, however, frequently of high importance. Where the quantitative analysis of a mineral is wanted, more expensive apparatus and a different method of procedure are needed, for which we must refer to treatises on analytic chemistry, especially the works of G. Rose, Rammelsberg, and other authors. In mineralogy two methods of testing minerals are employed, the one by heat chiefly applied through the blowpipe, the second by acids and other reagents in solution.

Use of the Blowpipe.

The blowpipe in its simplest form is merely a conical tube of brass or other metal, curved round at the smaller extremity, and terminating in a minute circular aperture not larger than a fine needle. Other forms have been proposed, one of the most useful being a cone of tin open for the application of the mouth at the smaller end, and with a brass or platina beak projecting from the side near the other or broad end. With this instrument a stream of air is conveyed from the mouth to the flame of a lamp or candle, so

that this can be turned aside, concentrated, and directed upon any small object. The flame thus acted on is seen to consist of two parts—the one nearest the beak of the blowpipe forming a blue obscure cone, the other external to this being of a shining yellow or reddish-yellow colour. The blue cone consists of the inflammable gases not yet fully incandescent, and the greatest heat is just beyond its point, where this is fully effected. The blue flame still needs oxygen for its support, and consequently tends to withdraw it from any body placed within its influence, and is named the reducing flame. At the extremity of the yellow cone, on the other hand, the whole gases being consumed and the external air having free access, bodies are combined with oxygen, and this part is named the oxidating flame. Their action being so distinct, it is of great importance for the student to learn to distinguish accurately these two portions of the flame from each other. This is best done by experimenting on a piece of metallic tin, which can only be kept pure in a good reducing flame, and acquires a white crust when acted on by the oxidating flame.

The portion of the mineral to be examined should not be larger than a peppercorn, or a fine splinter a line or two long. It is supported in the flame either by a pair of fine pincers pointed with platinum, or in slips of platinum foil, or on charcoal. Platinum is best for the siliceous minerals, whereas for metallic substances charcoal must be employed. For this purpose solid uniform pieces must be chosen, and a small cavity formed in the surface in which the mineral to be tested can be deposited. For fuller details on manipulation we must refer to works treating expressly on this subject.*

In examining a mineral by heat, it should be first tested alone and then with various reagents. When placed alone in a matrass or tube of glass closed at one end, and heated over a spirit lamp, water or other volatile ingredients, mercury, arsenic, tellurium, often sulphur or fluorine, may readily be detected, being deposited in the cooler part of the tube or acting on the glass. It may next be tried in an open tube of glass, through which a more or less strong current of air passes according to the inclination at which the tube is held, so that volatile oxides or acids may be formed; and in this way the chief combinations of sulphur, selenium, tellurium, and arsenic are detected. On charcoal, in the reducing flame arsenic, and in the oxidating flame selenium or sulphur, are shown by their peculiar odour; antimony, zinc, lead, and bismuth leave a mark or coloured ring on the charcoal; and other oxides and sulphurets are reduced to the pure metal. On charcoal or in the platinum pincers the fusibility of minerals is

* See Berzelius die Anwendung des Lothrohres; Plattner die Probirkunst mit dem Lothrohre; Griffin on the Blowpipe, &c.

tested, and some other phenomena should be observed, as whether they intumesce (bubble up), effervesce, give out fumes, become shining, or impart a colour to the flame. The degree of fusibility or the ease with which a mineral is melted should also be observed; and to render this character more precise, von Kobell has proposed this scale:—(1.) Antimony glance, which melts readily in the mere candle flame; (2.) Natrolite, which in fine needles also melts in the candle flame, and in large pieces readily before the blowpipe; (3.) Almandine (garnet, from Zillerthal), which does not melt in the candle flame even in fine splinters, but in large pieces before the blowpipe; (4.) Strahlstein (hornblende from Zillerthal) melts with some difficulty, but still more readily than (5.) Orthoclase (or adularia felspar); and (6.) Bronzite or diallage, of which only the finest fibres can be rounded by the blowpipe. In employing this scale, fine fragments of the test minerals, and of that to be tried, and nearly of equal size, should be exposed at the same time to the flame. A more common mode of expressing fusibility is to state whether it is observable in large or small grains, in fine splinters, or only on sharp angles. The result or product of fusion also yields important characters, being sometimes a glass, clear, opaque, or coloured; at other times an enamel, or a mere slag.

The most important reagents for testing minerals with the blowpipe are the following. (1.) Soda (the carbonate), acting as a flux for quartz and many silicates, and especially for reducing the metallic oxides. For the latter purpose, the assay (or mineral to be tried) is reduced to powder, kneaded up with moist soda into a small ball, and placed in a cavity of the charcoal. Very often both the soda and assay sink into the charcoal, but by continuing the operation they either again appear on the surface, or, when it is completed, the charcoal containing the mass is finely pounded and washed away with water, when the reduced metal is found in the bottom of the vessel. As a very powerful agent for reduction Fresenius recommends equal parts of carbonate of soda and cyanide of potassium (cyankalium). (2.) Borax (biborate of soda) serves as a flux for many minerals, which are best used in small splinters. The borax when first exposed to the flame swells up or intumesces greatly, and it should therefore be first melted into a small bead, in which the assay is placed. During the process the student should observe whether the assay melts easily or difficultly, with or without effervescence, what colour it imparts to the product both when warm and when cold, and also the effect both of the oxidating and reducing flames. (3.) Microcosmic salt or salt of phosphorus (phosphate of soda and ammonia) is specially important as a test for metallic oxides, which exhibit far more decided

colours with it than with borax. It is also a useful reagent for many silicates, whose silica is separated from the base and remains undissolved in the melted salt.

Less important are the following substances only employed for a few particular purposes. (4.) Vitrified boracic acid, used as an indispensable test of phosphoric acid. (5.) Gypsum and fluor spar as mutual tests, fusing together into a mass which is a clear glass when hot, but changes to a white enamel on cooling. (6.) Solution of cobalt (nitrate of cobalt dissolved in water), or dry oxalate of cobalt, serve as tests of alumina, magnesia, and zinc oxide, (7.) Oxalate of nickel forms a test of potassa where soda and lithia also occur. (8.) Tin, in slips of foil rolled up, which are dipped into the fused assay and promote complete reduction by abstracting oxygen. (9.) Iron, as harpsicord wire, used as a test of phosphorus and a mean of precipitating lead, copper, nickel, and antimony, which separate from sulphur or acids when the wire is dipped in the fused assay. (10.) Silica with soda, as a test of sulphur and sulphuric acid. (11.) Oxide of copper, as a test of chlorine and iodine.

In examining minerals in the moist way, the first point to be considered is their solubility, as on this the whole of the procedure depends. Three degrees of solubility may be noted: (1.) minerals soluble in water; (2.) minerals soluble in muriatic or nitric acid; and (3.) those unaffected by any of these fluids. The minerals soluble in water, or hydrolytes, are either acids (almost only the boracic acid or sassolin and the arsenious acid), or oxygen or haloid salts. These are easily tested, one part of the solution being employed to find the electropositive element or basis, the other the electronegative or acid. The following bases have been found in soluble minerals, ammonia, potassa, soda, lime, magnesia, alumina, the protoxide and peroxide of iron, the oxides of zinc, copper, cobalt, uranium, and the protoxide of mercury; the acids are, the carbonic, sulphuric, nitric, and boracic acids, to which chlorine must be added.

Minerals insoluble in water may next be tested with the above acids; the nitric acid being preferable when it is probable, from the aspect of the mineral or its conduct before the blowpipe, that it contains an alloy, a sulphuret or arseniate of some metal. In this manner the carbonic, phosphoric, arsenic, and chromic acid salts, many hydrous and anhydrous silicates, many sulphurets, arseniates, and other metallic compounds, are dissolved, so that further tests may be employed.

The minerals insoluble either in water or these acids are sulphur, graphite, cinnabar, some metallic oxides, some sulphates, and compounds with chlorine and fluorine, and especially quartz, and various

silicates. For many of these no test is required, or those furnished by the blowpipe are sufficient. The silicates and others may be fused with four times their weight of anhydrous carbonate of soda when they are rendered soluble, so that further tests may be applied.*

Chemical Reaction of the more Important Elements.

It is not intended in this place to describe the chemical nature of the elementary substances, and still less to enumerate the whole of those marks by which the chemist can detect their presence. Our object is limited principally to the conduct of minerals before the blowpipe, and to a few other tests by which their more important constituents may be discovered by the student.

I. NON-METALLIC ELEMENTS,
and their combinations with oxygen.

Nitric Acid.—Most of its salts detonate when heated on charcoal. In the closed tube they form nitrous acid, easily known by its orange colour and smell; a test more clearly exhibited when the salt is mixed with copper filings and treated with concentrated sulphuric acid. When to the solution of a nitrate, a fourth part of sulphuric acid is added, and a fragment of green vitriol placed in it, the surrounding fluid becomes of a dark brown colour.

Sulphur and its compounds, in the glass tube or on charcoal, form sulphurous acid, easily known by its smell; the sulphuret of arsenic and mercury sublime in the closed tube; and some other sulphurets, as iron-pyrites, part with a portion of their sulphur. The minutest amount of sulphur or sulphuric acid may be detected, by melting a very small fragment of the mineral with soda and silica, when the bead is coloured yellow or brown, from sulphuret of sodium. A surer method is to melt the pulverised assay with 2 parts soda and 1 part borax, and to lay the bead moistened with water on a plate of clean silver, which is then stained brown or black. To determine whether the mineral contains sulphur or sulphuric acid v. Kobell recommends this process: Boil the pulverised assay in a solution of potash to dryness, heat it till the alkali begins to melt; dissolve and filter, and put into the filtered liquid a piece of clear silver; this will be stained black if the mineral contained uncombined sulphur. In this way the sulphur found in hauyne, helvine, and lapis-lazuli may be shown. In solutions sulphuric acid is best detected by chloride of baryum (chlor-

* Further information will be found in:—
Rammelsberg's Leitfaden für die qualitative chemische Analyse. Berlin, 1843.
Fresenius, Anleitung zur qual. chem. An., 3te Auf. Braunschweig, 1846;
and especially in the classic work of Heinrich Rose, Handbuch der analytischen Chemie, 3te Aufl. Berlin, 1834.

baryum), which forms a heavy white precipitate, insoluble in muriatic or nitric acid. Acetate of lead forms a similar deposit, soluble, however, in hot, concentrated muriatic acid.

Phosphoric Acid.—Most combinations with this acid are said by Erdmann to tinge the blowpipe flame green, especially if previously moistened with sulphuric acid. The experiment must be performed in the dark, when even three per cent. of the acid may be detected. For a larger proportion, the assay is melted with boracic acid on charcoal in the oxidating flame; a small piece of iron wire is stuck into the melted bead, and the whole heated in the reducing flame. Phosphuret of iron is thus formed, which, when the bead after cooling is broken by a hammer, is found among the fragments as a black magnetic grain. This test, however, only succeeds when no sulphuric acid, arsenic acid, or metallic oxides reducible by iron are present. In solution, phosphoric acid, with muriate of magnesia, forms, on addition of ammonia, a white crystalline precipitate, which is soluble in acids but *not* in sal-ammonia: the precipitate with acetate of lead also, when fused before the blow-pipe, cools into a crystallized grain.

Selenium and *Selenic Acid* are readily detected by the strong smell of decayed horse-raddish, which even a very small quantity will produce. It leaves a grey deposit with a metallic lustre on the charcoal. When roasted in the open tube, selenium is often deposited as a red sublimate.

Chlorine and its salts. When oxide of copper is melted with salt of phosphorus into a very dark-green bead, and an assay containing chlorine fused with this, the flame is tinged of a beautiful reddish blue colour, till all the chlorine is driven off. Other salts of copper produce the same colour fused alone, but not with salt of phosphorus. If very little chlorine is present, the assay is dissolved in nitric acid, (if not soluble originally it must first be melted with soda on platinum wire), and the diluted solution gives, with nitrate of silver, a precipitate of chloride of silver, which is first white, but on exposure to the light becomes gradually brown, and at length black. It also dissolves *readily* in ammonia, but not in nitric acid.

Iodine and its salts, treated like chlorine, impart a very beautiful bright green colour to the flame; and heated in the closed tube with sulphate of potash, yield violet-coloured vapours. In solution it gives with nitrate of silver a precipitate similar to chlorine, but which is very difficultly soluble in ammonia. Its surest test is the blue colour it imparts to starch, best seen by pouring concentrated sulphuric acid over the mineral in a test tube, which has a piece of paper or cotton covered with moist starch over its mouth.

Bromine and its salts, treated in the same manner with salt of phosphorus and oxide of copper, colour the blowpipe flame greenish-blue. In the closed tube with nitrate of potassa they yield bromine vapours, known by their yellow colour and peculiar disagreeable smell. Treated with sulphuric acid, bromine in a few hours colours starch pomegranate-yellow.

Fluorine, where it occurs accidentally in small amount, is shown by heating the assay in a closed tube with a strip of logwood paper in the open end. The paper becomes straw-yellow, and the glass is corroded. Where it is in large proportion, and more intimate combination, this test only appears when the assay is heated in the open tube with salt of phosphorus and part of the flame admitted to the tube. Another test is to heat the pulverised mineral with concentrated sulphuric acid in a shallow dish of platinum (or lead), over which a plate of glass covered with a coat of wax, through which lines have been drawn with a piece of sharp-pointed wood, is placed. If fluorine is present the glass is etched where exposed.

Boracic Acid.—The mineral is pounded, mixed with 1 part fluor spar, and 4½ parts sulphate of potassa, and fused. When melting it colours the flame momentarily green. If the assay be heated with sulphuric acid, and alcohol added, and set on fire, the flame is coloured green from the vapours of the boracic acid.

Carbon, pulverised and heated with saltpetre, detonates, leaving carbonate of potassa. Carbonic acid is not easily discovered with the blowpipe, but the minerals containing it effervesce in muriatic acid, and the colourless gas that escapes renders litmus paper red. In solution it forms a precipitate with lime-water, which is again dissolved with effervescence in acids.

Silica, before the blowpipe, alone is unchanged; is very slowly acted on by borax, very little by salt of phosphorus, but with soda melts entirely with a brisk effervescence into a clear glass. The silicates are decomposed by salt of phosphorus, the silica being left in the bead as powder or a skeleton. Most of them melt with soda to a transparent glass. There are two modifications of silica,—one amorphous, and soluble in water and acids; the other crystalline, and only acted on by fluoric acid. The former readily dissolves in a boiling solution of potassa, the latter only with much difficulty. Some silicates are dissolved in muriatic acid, and this the more readily the more powerful the basis, the less the proportion of silica, and the greater the amount of water they contain. Sometimes the acid only extracts the basis, leaving the silica as a powder or jelly; or the silica, too, is dissolved, and only gelatinizes on evaporation. The insoluble silicates may be first melted with some carbonate of an alkali,

when the solution gelatinizes, and finally leaves a dry residuum, of which the part insoluble in warm muriatic acid has all the properties of silica.

II.—THE ALKALIS AND EARTHS.

Ammonia, heated with soda in a closed tube, is readily known by its smell. Its salts, heated with solution of potassa, also yield the vapour, known from its smell, its action on turmeric paper, and the white fumes that rise from a glass tube dipped in muriatic acid held over it.

Soda is known from the reddish-yellow colour imparted to the external flame when the assay is fused or kept at a strong red heat. In solution it is characterised rather by negative than positive marks, yielding no precipitate with chloride of platinum or sulphate of alumina, and with acetic acid fine needles, only when the solution is highly concentrated.

Lithia is best recognised by the beautiful carmine-red colour it imparts to the flame during the fusion of a mineral containing it in considerable amount. Where the proportion is small, Turner says that the same colour appears if the assay be mixed with 1 part fluor spar, and 1½ parts sulphate of potassa. But the presence of soda prevents this phenomenon, so that the amblygonite, with 7 per cent. lithia, shows only a flame of a yellow colour. In concentrated solutions it forms a precipitate with the phosphate and carbonate of soda, but none with bichloride of platinum, sulphate of alumina, or acetic acid.

Potassa is known by the violet colour imparted to the external cone, when the assay is heated at the extremity of the oxidating flame. The presence of lithia or soda, however, disturbs this reaction. It may still be discovered by melting the assay in borax glass coloured brown by nickel oxide, which is changed to blue by the potassa. In concentrated solutions of potassa the bichloride of platinum gives a citron-yellow, heavy, crystalline precipitate of chloride of platinum and potassium; acetic acid causes a white, granular, crystalline precipitate of binacetate of potassa; and sulphate of alumina, after some time, forms a deposit of alum-crystals. If ammonia is also present it must first be driven off. Potassa frequently cannot be discovered by the blowpipe, from its union with soda. When it is suspected to occur in this manner in a silicate, the assay, finely pulverized, should be melted with twice its volume of soda on charcoal, the fused mass again pulverized, dissolved in muriatic acid, evaporated, the residue dissolved in a little water, and tested as above.

Baryta.—The carbonate of this earth melts easily to a clear glass,

milk-white when cold; the sulphate is very difficultly fusible, but in the reducing flame is converted into sulphuret of baryum. When combined with silica it cannot be well discovered by the blowpipe. In solution, salts of baryta yield, with sulphuric acid and solution of gypsum, *immediately* a fine white precipitate, insoluble in acids or alkalis; and with silico-hydrofluoric acid a colourless crystalline precipitate.

Strontia, the carbonate, even in thin plates, only melts on the edges, and forms cauliflower-like projections of dazzling brightness; the sulphate melts easily in the oxidating flame, and in the reducing flame is changed into sulphuret of strontium, which, dissolved in muriatic acid, and evaporated to dryness, gives a fine carmine-red colour to the flame of alcohol. In other combinations strontia must be tested when in solution. It then gives a precipitate with sulphuric acid, and with sulphate of lime, but not *immediately;* and with silico-hydrofluoric acid forms no precipitate. Where it occurs along with baryta, the solution in muriatic acid should be evaporated to dryness, the residue heated to redness, pulverized and digested in alcohol, when the chloride of strontium is dissolved, the chloride of baryum left behind.

Lime occurs in so many combinations, that no general rule can be given for its detection by the blowpipe. The carbonate is rendered caustic by heat, when it has alkaline properties, and readily absorbs water. The sulphate in the reducing flame changes to the sulphuret of calcium, which is also alkaline. Sulphuric acid precipitates lime only from very concentrated solutions; oxalic acid even from very weak ones; and silico-hydrofluoric acid not at all. As baryta and strontia also form precipitates with the first two reagents, they must previously be separated by sulphate of potassa. Chloride of calcium tinges the flame of alcohol yellowish-red.

Magnesia, alone, or as a hydrate, a carbonate, and in some other combinations, when ignited with solution of cobalt, or the oxalate of cobalt, assumes a light red tint. It is not precipitated from solution either by sulphuric acid, oxalic acid, or silico-hydrofluoric acid; but phosphoric acid with ammonia throws down a white crystalline precipitate of phosphate of ammonia and magnesia.

Alumina alone is infusible, but if previously moist contracts and hardens. In many combinations, when ignited with solution of cobalt, it assumes a fine blue colour. It is thrown down by potassa or soda as a white voluminous precipitate, which in excess of the alkali is easily and completely soluble, but is again precipitated by muriate of ammonia. Carbonate of ammonia also produces a precipitate which is not soluble in excess.

Glucina, *Yttria*, *Zirconia*, and *Thorina* are not properly distinguished by blowpipe tests, though the minerals in which they occur are well marked in this way. In solution glucina acts with potassa like alumina; but the precipitate with carbonate of ammonia is again soluble, with excess of the alkali, and the two earths may thus be separated. Yttria is precipitated by potassa, but is not again dissolved by excess of the alkali. With carbonate of ammonia it acts like glucina. It must be observed, however, that the substance formerly named yttria is now considered a mixture of this earth with the oxides of erbium, terbium, and lanthanium. Zirconia acts with potassa like yttria, and with carbonate of ammmonia like glucina. Concentrated sulphate of potassa throws down a double salt of zirconia and potassa, which is very little soluble in pure water. In some zircons it seems mixed with noria, a new metallic oxide.

III.—THE METALS.

Arsenic and its sulphuret on charcoal yield fumes, with a smell like garlic, and sublime in the closed tube. The greater number of alloys of arsenic in the reducing flame leave a white deposit on the charcoal; or where it is in larger proportion, give out greyish-white fumes with a smell of garlic. Some alloys also yield metallic arsenic in the closed tube. In the open tube all of them yield arsenious acid, and those containing sulphur also sulphurous fumes. Many arsenic acid salts emit evident odours of arsenic when heated on charcoal with soda; and some sublime metallic arsenic when heated with pulverized charcoal in the closed tube. In other compounds and salts arsenic can only be detected in solution. For this purpose the assay is melted in the platinum-spoon with three to six times its bulk of saltpetre, to form arseniate of potassa. The melted mass is then digested with water, the solution concentrated, mixed with alcohol, and treated with acetic acid till all the potassa is thrown down and the fluid gives acid reaction. When clear, it is poured off, and decomposed by nitrate of silver, which produces a reddish-brown precipitate when arsenic is present.

Antimony melts easily on charcoal, emitting dense white fumes, and leaving a ring of white crystalline oxide on the support. In the closed tube it does not sublime, but burns in the open tube with white smoke, leaving a sublimate on the glass, which is easily driven from place to place by heat. Most of its compounds, with sulphur or with the other metals, show similar reaction. Antimony oxide on charcoal melts easily, fumes, and is reduced, colouring the flame pale greenish-blue. Sometimes the assay mixed with soda should be

heated on charcoal in the reducing flame when the characteristic deposit is produced.

Bismuth, melts easily, fumes, and leaves a yellow oxide on the charcoal. In the closed tube it does not sublime, and in the open tube scarcely fumes, but is surrounded by the fused oxide, which appears dark-brown when warm, and bright-yellow when cold. By these characters, and the easy reduction of its oxides, bismuth is readily recognised, even in combinations. The oxide with sulphuretted hydrogen forms a black precipitate, and by potassa or ammonia is thrown down as a white hydrate, which is not dissolved by excess of alkali. A great addition of water produces a white precipitate of very insoluble basic salt.

Tellurium fumes on charcoal, and becomes surrounded by a mark with a reddish border, which, when the reducing flame is turned on it, disappears with a bluish-green light. In the closed tube tellurium gives a sublimate of the grey metal; and in the open tube produces copious fumes, and a white powder which can be melted into small clear drops.

Mercury in all its combinations is volatile, and yields a metallic sublimate when heated alone, or with tin or soda in the closed tube.

Zinc, when heated with soda on charcoal, is reduced to the metallic state, but is again (and if abundant, with a bluish-green flame) converted into the oxide, which is deposited on the support. This deposit, when warm, is yellow; when cold, white; is tinged of a fine green by solution of cobalt, and is not further volatile in the oxidating flame. In solution the surest test of oxide of zinc is its precipitation by potassa as a white gelatinous hydrate, easily redissolved in excess of the alkali, but again thrown down by sulphuretted hydrogen, as white sulphuret of zinc.

Tin occurs chiefly as pyrites and tin-ore (sulphuret and oxide), and is known by the white deposit of the oxide left on the charcoal behind the assay, and which is not driven off, either by the reducing or oxidating flame, but takes a bluish-green colour from the solution of cobalt. The oxide is reduced by soda, and this even when a very small proportion of tin is present as a mere accidental element.

Lead, in union with sulphur and other metals, is known by the sulphur-yellow deposit of the oxide left on the charcoal when heated in the oxidating flame. Its salts treated with soda in the reducing flame on charcoal are known both by the mark of the oxide and the reduction of the metallic lead. The solutions of its salts are colourless, but give a black precipitate with sulphuretted hydrogen. Muriatic acid throws down chloride of lead, not acted on by ammonia, but so-

luble in a large quantity of hot water. Sulphuric acid causes a white, chromate of potassa a yellow precipitate.

Cadmium, found in some ores of zinc and in greenockite, produces, with soda, a reddish-brown or orange-yellow ring on the charcoal, and also on platinum foil.

Manganese, when no other metal is present to give a colour to the flux, is readily known by the assay melted with borax or salt of phosphorus on the platinum wire in the oxidating flame, forming a fine amethystine glass, which becomes colourless in the reducing flame. In combination with other metals, the pulverised assay mixed with two or three times as much soda, and melted in the oxidating flame on platinum foil, forms a bluish-green glass. This is the surest test of manganese, being so delicate, that even a thousandth part of the metal in the assay imparts a green colour to the flux. Potassa or ammonia throw down from solutions of its salts the protoxide of manganese as a white hydrate, which, in the air, becomes gradually dark-brown, and is not again dissolved by carbonate of ammonia.

Cobalt is usually easily discovered. In minerals with a metallic aspect, the assay is first roasted on charcoal, and then melted with borax in the oxidating flame, when a beautiful blue glass is produced. Minerals of non-metallic aspect may be at once melted with borax. In many cases (where manganese, iron, copper, or nickel are also present) the blue colour only appears distinctly, after the glass has been for some time heated in the reducing flame. The salts of protoxide of cobalt form bright red solutions, from which potassa throws down a blue flaky hydrate, which becomes olive-green in the air, and can be again dissolved by excess of carbonate of ammonia.

Nickel is generally very readily discovered by the assay, first roasted in the open tube and on charcoal, producing in the oxidating flame with borax a glass, which hot is reddish or violet-brown; when cold, yellowish or dark red; and by the addition of saltpetre changes to blue;—by which the oxide of nickel may be distinguished from that of iron. In the reducing flame the colour vanishes, and the glass appears grey, from the finely-divided particles of the metal. With salt of phosphorus the reaction is similar, but the glass is almost colourless when cold. The salts in solution have a bright green colour, and with potassa form a green precipitate of hydrated nickel-oxide, which is unchanged in the air, but again dissolved in carbonate of ammonia.

Copper may in most cases be discovered by melting the assay (if apparently metallic, first roasted) with borax or salt of phosphorus in the oxidating flame, when an opaque reddish-brown glass is produced, a small addition of tin aiding in the result. In the reducing

flame the glass, when warm is green, when cold blue. With soda metallic copper is produced. A small proportion of copper may often be detected by heating the assay, moistened with muriatic acid, in the oxidating flame, which is then tinged of a beautiful green colour. Solutions of its salts are blue or green, and produce a brownish-black precipitate, with sulphuretted hydrogen. Ammonia at first throws down a pale-green or blue precipitate, but in excess again produces a very fine blue colour. Cyanate of iron and potassium, even in weak solutions, gives a dark reddish-brown precipitate; and iron throws down copper in the metallic state.

Silver in the metallic state is at once known, and from many combinations can be readily extracted on charcoal. Other combinations, and the metallic sulphurets in which it is incidentally present are thus tested. The pulverized assay, mixed with borax glass and lead, is melted by the reducing flame in a hollow of the charcoal, and then kept for some time in the oxidating flame, by which a granule of argentiferous lead is obtained. This lead is then melted by the oxidating flame in a small cupel of bone ashes, previously ignited, and the heat continued till it is mostly changed into litharge. The very argentiferous lead grain is now heated in another cupel, into which the lead sinks and leaves behind a grain of silver, sometimes cupreous or auriferous. From its solution in nitric acid silver is thrown down by muriatic acid as a white chloride, which in the light soon becomes black, is soluble in ammonia, and can be again precipitated from this solution by nitric acid, as chloride of silver.

Gold when pure is readily known, and is easily separated from its combinations with tellurium on charcoal. If the grain is white, it contains more silver than gold, and must then be heated in a porcelain capsule with nitric acid, which gives it a black colour, and gradually removes the silver, if the gold is only a fourth part or less. If the proportion of gold is greater, the nitro-muriatic acid must be used, which then removes the gold. From its solution in this acid the protochloride of tin throws down a purple precipitate *(purple of Cassius)*, and the sulphate of iron, metallic gold.

Platinum and the metals usually found with it cannot be separated from each other by heat. Only the *Osmium-iridium* strongly heated in the closed tube with saltpetre is decomposed, forming osmium acid, known from its peculiar pungent odour. The usual mixture of platinum grains is soluble in nitro-muriatic acid, leaving behind those of osmium-iridium. From this solution the *platinum* is thrown down by sal-ammonia as a double chloride of platinum and ammonium. From the solution evaporated, and again diluted, with cyanide of mercury, the *palladium* separates as cyanide of palladium. The *rhodium* may

be separated by its property of combining with fused bisulphate of potassa, which is not the case with platinum or iridium.

Cerium, in minerals that contain no other metal colouring the flux (especially no iron-oxide), is easily known by producing with borax and salt of phosphorus in the oxidating flame a red or dark-yellow glass, which becomes very pale when cold, and colourless in the reducing flame. Cerium-oxide is often combined with oxides of lanthanium and didymium, which were confounded with it before they were recognised as independent metals.

Iron, the peroxide, and hydrated peroxide, become black and magnetic before the blowpipe. Ferruginous minerals form with borax (salt of phosphorus is similar) in the oxidating flame a dark-red glass becoming bright-yellow when cold; and in the reducing flame, especially on adding tin, an olive-green or mountain-green glass. Yet some precautions are necessary when cobalt, copper, nickel, chrome, or uranium, are also present; and when the iron is combined with sulphur or arsenic the assay should be first roasted. Salts of protoxide of iron form a green solution, from which potassa or ammonia throws down the protoxide as a hydrate, which is first white, then dirty-green, and finally yellowish-brown. Carbonate of lime produces no precipitate. Ferrocyanide of potassium produces a voluminous bluish-white precipitate becoming deep blue in the air; whilst the ferridcyanide of potassium causes a beautiful blue precipitate. The salts of the peroxide, on the other hand, form yellow solutions, from which the peroxide is thrown down by potassa or ammonia, as a flaky-brown hydrate. Carbonate of lime also causes a precipitate. Ferrocyanide of potassium produces a very fine blue precipitate; the ferridcyanide no precipitate.

Chromium.—Most minerals containing this metal are distinctly characterised by forming with borax, or salt of phosphorus, a glass fine emerald green when cold, though when hot often yellowish or reddish. Usually this reaction is best seen in the reducing flame, but when oxide of lead or copper is present, in the oxidating. Where the proportion of chrome is small it must often be tested in solutions. These are usually at once known by their green colour, and the metal is thrown down by potassa as a bluish-green hydrate, again dissolved in excess of the alkali. The chrome in many minerals is very certainly discovered by melting the assay with three times its bulk of saltpetre, forming chromate of potassa, which dissolved in water gives with acetate of lead a yellow precipitate of chromate of lead.

Vanadium, as vanadic acid, melted on platinum wire with borax or salt of phosphorus, gives a fine green glass in the reducing flame,

which becomes yellow or brown in the oxidating flame, distinguishing it from chrome.

Uranium, in most minerals, is known by yielding with salt of phosphorus, in the oxidating flame a clear yellow, in the reducing flame a fine green glass. With borax its reaction is similar to that of iron.

Molybdenum, found only in a few minerals, is known by forming in the reducing flame, with salt of phosphorus, a green, with borax a brown glass,—the latter separating it from other metals which form a green glass with borax also.

Tungsten or *Wolfram* occurs in minerals only as tungstic acid. It may often be known by forming with salt of phosphorus, in the oxidating flame, a colourless or yellow, in the reducing flame a very beautiful blue glass, which appears green when warm. When accompanied by iron the glass is blood-red, not blue. A more generally applicable test is, to melt the assay with five times as much soda in a platinum spoon, dissolve it in water, filter, and decompose the result with muriatic acid, which throws down the tungstic acid, which is white when cold, but citron-yellow when heated.

Tantalium, occurring as tantalic acid, is difficultly discovered by the blowpipe. Salt of phosphorus dissolves it readily and in large quantity into a colourless glass, which does *not* become opaque in cooling, and does *not* acquire a blue colour from solution of cobalt—characters at least distinguishing it from glucina, yttria, zirconia, and alumina. Its presence is best shown by the following process. Fuse the assay with two times as much saltpetre, and three times as much soda, in a platinum spoon; dissolve this, filter, and decompose the fluid by muriatic acid: the tantalic acid separates as a white powder, which does *not* become yellow when heated.

Titanium occurs either as the oxide or titanic acid. The latter, in anatase, rutile, brookite, and titanite, is shown by the assay forming with salt of phosphorus, in the oxidating flame, a glass which is and remains colourless; in the reducing flame, a glass which appears yellow when hot, and whilst cooling passes through red into a beautiful violet. When iron is present, however, the glass is blood-red, but is changed to violet by adding tin. When titanate of iron is dissolved in muriatic acid, and the solution boiled with a little tin, it acquires a violet colour from the oxide of titanium. Heated with concentrated sulphuric acid, the titanate of iron produces a blue colour-

CHAPTER IV.

CLASSIFICATION OF MINERALS.

In a previous part of this treatise a mineral species was defined as a natural inorganic body, possessing a definite chemical composition, and peculiar external form. The limitations with which this definition is to be understood have been pointed out in the account given of these various classes of properties. From this it appears that the form of a mineral species comprehends not only the original or fundamental figure, but all those that may be derived from it by the established laws of crystallography. Irregularities of form, proceeding from accidental causes, in like manner, do not interfere with the strictness of the definition, nor yet that absence of form which results from the limited space in which the mineral has been produced. Even apparently amorphous masses, when the chemical composition remains unaltered, are properly classed under the same species, as we may suppose at least the tendency to assume the true form still to exist.

The definite chemical composition of mineral species must be taken with equal latitude. Pure substances, such as they are described in works on chemistry, are very rare in the mineral kingdom. In the most transparent quartz crystals traces of alumina and iron oxide can be detected; the purest spinel contains a small amount of silica, and the most brilliant diamond, consumed by the solar rays, leaves some ash behind. Such non-essential mixtures must be neglected, or each individual crystal would form a distinct mineral species. The isomorphous elements introduce a wider range of varieties, and render the limitation of species more difficult. Carbonate of lime, for instance, becomes mixed with carbonate of magnesia or of iron, in almost innumerable proportions; and the latter substances also with the former. Where these mixtures are small in amount, variable in different specimens, and do not greatly affect the form or physical characters of the predominant element, they may safely be neglected, and the mineral reckoned to that species with which it most closely agrees. Where, however, the mixture is greater, and the two substances are frequently found in definite chemical proportions, these

compounds must be considered as distinct species, especially should they also show differences in form and other external characters.

Amorphous minerals with definite composition must also be considered as true species, though circumstances may prevent them assuming a distinct crystalline form. But when amorphous masses show no definite composition, as in many substances classed as clays and ochres, they cannot be accounted true mineral species, and properly ought not to be included in a treatise on mineralogy. Some of them, however, from their importance in the arts, others from other circumstances, have received distinct names, and a kind of prescriptive right to a place in mineralogical works, from which they can now scarcely be banished. Many of them are properly rocks, or indefinite combinations of two or more minerals; others are the mere products of the decomposition of such bodies. Their number is of course indefinite, and their introduction into the system tends much to render mineralogy more complex and difficult, and to destroy its scientific character.

In collecting the species into higher groups, and arranging them in a system, two wholly opposite methods have been pursued. Some have looked only at the external characters, and asserted that they alone were sufficient for all the purposes of arranging and classifying minerals. Others have, on the contrary, taken chemistry as the foundation of mineralogy, and classed the species by their composition, without reference to form or physical characters. Mohs may be regarded as the founder and most distinguished advocate of the former school, and perhaps the only person who has ever endeavoured fully to develop such a system. With him mineralogy is a wholly independent science, which needs to borrow nothing from any other—nothing from chemistry, nothing from geology, or geography. It must depend solely on external characters, of which he chooses three as especially adapted to form the basis of a system, namely, the crystalline form, the hardness, and specific gravity. Chemical characters he altogether excludes, because, as he asserts, natural history cannot make use of those properties that require for their observation the destruction or alteration of the body to which they belong. Such an argument will convince few in the present day; and even his followers now introduce the chemical nature of the species into their descriptions, and employ chemical characters as means for their discrimination. The neglect of this most important element in the original institution of the system operated much to its prejudice, and the author further encumbered it with a systematic nomenclature, which has never found its way into science. The accurate study of crystallography which it demands, though in reality one of

the highest merits of the system, has also prevented it from ever becoming popular.

The other, no less one-sided, school regards chemistry as the only true foundation of mineralogy, which, it asserts, is in truth only one particular department, or small corner, of the larger science. The chief supporter of this doctrine is Berzelius, the celebrated Swedish chemist, whose merits in extending the chemical knowledge of minerals, and placing this subject on a scientific basis, can never be too highly appreciated. But even he has failed to establish a system of chemical mineralogy which has been at all generally adopted. His classification is indeed highly artificial, as is shown by the ease with which he changed the basis of the arrangement from the electropositive to the electronegative element. His system, too, fails in some great requisites of a useful classification. Thus the groups which it forms are of very unequal value and extent; the silicates, for example, comprising more than a third of the mineral kingdom, ranking with the oxalates, mellitates, and molybdates, each containing only one or two species. Again, the minerals conjoined have often very dissimilar characters, so that a knowledge of one gives us no acquaintance with the peculiarities of the others. Thus native gold, the diamond, native tellurium, antimony, arsenic, sulphur, follow in immediate succession as simple substances; earthy cobalt, quartz, opal, sassoline, titanic acid, are conjoined on the ground of their being oxides. On the other hand, hornblende appears in five places of the system, augite in six, and the garnet in no less than nine, according to the predominance of different isomorphic elements. But the most important error is, we believe, the principle assumed as the foundation of the whole system, "that nothing except the composition should form an element in the arrangement of minerals." This implies that they must be regarded simply as substances, and not as individual objects, a view to which we have already stated our objections. Berzelius affirms that minerals should be arranged according to what they are *(was sie sind)*, and not according to how they appear *(wie sie aussehen)*. But here again there is an assumption made, that chemical composition alone determines what a body *is*, and that crystalline form, hardness, gravity, colour, and similar properties, are altogether unessential,—an assumption which nature does not by any means justify.

A true classification of minerals should take into account all their characters, and that in proportion to their relative importance. Among these the chemical composition undoubtedly holds a high rank, as being that on which the other properties will probably be ultimately found to depend; but it must be the general chemical cha-

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racter, not the special electro-chemical nature of the compound. Next in order is their crystalline form, especially as exhibited in cleavage; and then their other characters of gravity, hardness, and tenacity. But the various properties of minerals are as yet far from showing that subordination and co-relation which has been observed in the animal and vegetable kingdoms, where the external forms and structures have a direct reference to the functions of the living being. Hence even when all the characters are taken into account, there is not that facility in classifying the mineral that is presented by the other kingdoms of nature. Many, or rather most, of the species stand so isolated from all others, that it is scarcely possible to find any general principle on which to collect them into larger groups, especially such groups as, like the natural families of plants and animals, present important features of general resemblance, and admit of being described by certain common characteristics. Hence even among those authors who have adopted what has been named the mixed system of classification, in which all the characters are taken into account, considerable diversity prevails. Certain groups of species are indeed united by such evident characters, that they are found together in almost every method; but other species are not thus united, and the general order of arrangement is very uncertain. It thus happens that almost every author has his own classification, and the number might be indefinitely increased.

The statements just made show that the time for forming a perfect, or even nearly perfect, system of mineralogy has not yet arrived. Some, however, of very considerable merit have already been proposed, as those of Naumann, Glocker, and Weiss. We have chosen the latter, as developed by Hartmann, for the basis of that arrangement adopted in this treatise, making only such changes as the progress of the science seemed to render desirable. The general principles of this system are explained by Professor Weiss in the first volume of Karstein's Archiv für Mineralogie, and by Hartmann in his Manual. The following observations, chiefly borrowed from these sources, will sufficiently exhibit its general method.

A natural system must, in combining and dividing the objects which it has to classify, take account of all their properties, and assign them a place in the system, from a due consideration of their whole nature. It is this distinguishes it from an artificial system, which classifies objects with reference only to a single character.

Besides species, two higher grades in classification seem sufficient at once to exhibit the natural relations, and to facilitate an easy and complete review of the species composing the mineral kingdom. These are named families and orders. In forming the families, Pro-

fessor Weiss first selected those minerals which occupy the more important place in the composition of rocks, and consequently in the crust of the globe. Thus quartz, felspar, mica, hornblende, garnet, among siliceous minerals; calc-spar, gypsum, rock-salt, less so fluor spar and heavy spar, among those of saline composition, stand out prominently as the natural centres or representatives of so many distinct families. To these certain metallic minerals, as iron pyrites, lead-glance, or galena, blende, magnetic iron ore, the sparry iron ore, and a few more, are readily associated as other important families. But the minerals thus geologically distinguished are not sufficient to divide the whole natural kingdom into convenient groups, and additional species must be selected from the peculiarity of their natural-historical, or chemical properties. Thus the zeolites are easily seen to form such a natural group. The precious stones or gems also, notwithstanding their diverse chemical composition, must ever appear a highly natural family, when regarded as individual objects. Their great hardness, tenacity, high specific gravity without the metallic aspect, their brilliant lustre, transparent purity, and vivid colours,—all mark them out as a peculiar distinct family. Only the diamond, which might naturally seem to take the chief place in this class, differs so much, not only in elementary composition, but in physical properties, that it must be assigned to a diverse place in the system.

Round these species thus selected the other less important minerals are arranged in groups or families. It is evident that no general definition of these families can be given, as the connection is one of resemblance in many points, not of identity in any single character. In other words, it is a classification rather according to types than from definitions, as every true natural classification must be. The same cause, however, leaves the extent of the families somewhat undefined, and also permits considerable license in the arrangement of species. But both circumstances are rather of advantage in the present state of the science, as allowing more freedom in the grouping of species than could be obtained in a more rigid system of classification.

In collecting the families into orders, Professor Weiss follows rather the guidance of chemistry than of natural history, though also taking the latter into consideration. He gives chemical names to these orders, but still regards them *as names*, derived from the prevailing chemical characters, and *not as definitions*. Hence it must not be considered an error should two or three mineral species find their way into an order, with whose name, viewed as a definition, they may seem not to agree.*

* "De tous les classements," says Dr Ami Boué, "établis pour l'étude de la minéralogie, celui de M. Weiss, de Berlin, m'a paru le plus convenable pour un cours, parce qu'il donne

Guided by these and similar considerations, for which we must refer to his original memoir, Professor Weiss has formed the following classification of minerals. In this place we mention only the orders and families, reserving an enumeration of the species for another part of the work, where it will be more useful to the student.

I. Order.—The Oxidized Stones.

Families:—1. Quartz.
2. Felspar.
3. Scapolite.
4. Haloid stones.
5. Zeolite.
6. Mica.
7. Hornblende.
8. Clays.
9. Garnet.
10. Gems.
11. Metallic stones.

II. Order.—Saline Stones.

Families:—1. Calc-spar.
2. Fluor spar.
3. Heavy spar.
4. Gypsum.
5. Rock salt.

III. Order.—Saline Ores.

Families:—1. Sparry iron ores.
2. Copper salts.
3. Lead salts.

IV. Order.—Oxidized Ores.

Families:—1. Iron ores.
2. Tinstone.
3. Manganese ores.
4. Red copper ores.
5. White antimony ores.

V. Order.—Native Metals.

Form only one family.

VI. Order.—Sulphuretted Metals.

Families:—1. Iron pyrites.
2. Galena.
3. Grey antimony ore.
4. Grey copper ore.
5. Blende.
6. Ruby-blende.

VII. Order.—The Inflammables.

Families:—1. Sulphur.
2. Diamond.
3. Coal.
4. Mineral resins.
5. Combustible salts.

la facilité de réunir la cristallographie et la chimie minéralogique aux groupements artificiels et naturels sur lesquels M. Mohs a basé uniquement son système. L'établissement rationnel de l'espèce mineralogique est le seul but de M. Weiss, qui ensuite groupe ses espèces de la manière naturelle dont elles frappent les yeux les moins exercés. Il cherche seulement à faciliter au commençant l'étude de la science, et reconnait qui le chimiste, comme le crystallographe, doivent se construire chacun un classement particulier."

On this classification only a few additional remarks seem needed. Though introduced into the scheme, Weiss still regards the clays and similar amorphous substances as not genuine species. In Hartmann's treatise many of the less known minerals whose position in the system is uncertain, are placed in an appendix in alphabetical order. In the present volume these have been introduced into the system, along with the species to which they seemed most nearly allied, and on whose character they seemed to throw light. This has been done in the belief that an error in assigning them a place in a system which, like every other, is in many points only conventional, is less prejudicial than leaving them wholly isolated. These species are rarely of much importance, and the chief doubt often was, whether they should not rather be entirely omitted. We have also felt at full liberty to alter the arrangement of the species formerly included, whenever recent investigations might require it. For such changes, which are, however, few and seldom of much consequence, the author of the present work is alone responsible.

In describing the several species the following is the general plan adopted. First, that name which it seems most expedient to employ is given with such synonyms as are used in the more important English, French, and German works, especially those of Phillips, Hauy, and Mohs. Secondly, the system of crystallization is named, and the mineral more minutely characterized in the tesseral system, by enumerating the chief forms and combinations; in the tetragonal by the dimensions of the middle edge of the fundamental form, P; in the hexagonal, when holohedral, also by those of the middle edge of P, or when rhombohedral of the polar edge of the rhombohedron R. Rhombic minerals are described by the angles of any two of the prisms more commonly occurring, usually the prism ∞P and one of the two domes, $\breve{P}\infty$ or $\bar{P}\infty$, in the latter the polar edge being always the one mentioned;—more rarely the angles of the pyramid P are given. In monoclinohedric minerals the obtuse angle *C*, and the anterior (clinodiagonal) lateral edge of the prism ∞P, together with the polar edge of a hemipyramid, a clinodome, or a hemidome, are stated. In triclinohedric minerals the angles observed in the more common forms are enumerated. The forms and combinations are in general those selected by Naumann, and will be easily understood from the figures given in the former part of the treatise, but the more interesting and important minerals are further illustrated by figures of the crystals, mostly from Mohs and Haidinger.

Thirdly, the physical properties of the mineral are described, including its state of aggregation, cleavage, and fracture, hardness (H), and specific gravity (G). Then follow its relation to light, or its

transparency, refraction, and polarization, lustre, colour, and streak; and also its phosphorescence, electricity, and magnetism, where these properties are either peculiar or characteristic. The chemical reaction of the mineral, especially its conduct before the blowpipe (B.B.), and the effect of acids, is next noticed as important discriminating characters. Its chemical compositition (Chem. Com.) or probable formula, follows, with at least the more important and recent analyses. By arranging these in a different mode from that usually adopted, we have been enabled to give more of them (in smaller space), and in a form better suited for comparison than will be found, we believe, in any other English work. For this portion of the work our principal authority has been the very elaborate and valuable treatise of Rammelsberg,—the formulæ of the silicates being, however, those of Naumann after L. Gmelin.*

The latter part of the description includes notices of any peculiarities regarding the species, its uses in the arts, its geognostic mode of occurrence, the most important localities where it has been found, and many other miscellaneous particulars, which could not properly be introduced in the former portion.

It will thus be seen that the characteristic or determinative characters of the species, are comprised in that portion of the description which precedes the analyses or the chemical composition; whilst what follows this is miscellaneous and general information, which, though important as contributing to the complete knowledge of the species, does not yet enter into its discriminative character.

The nomenclature of mineralogy is in so unsettled a state, that there is much difficulty in choosing names for the species. It is highly desirable that these names should be such as can pass current in all languages, so that in reading or consulting foreign works the student may not have always a new nomenclature to learn. In other departments of natural history a Latin terminology, with generic and specific names, has been introduced, and Breithaupt, Dana, and Glocker have endeavoured to form such a language for mineralogy. But this science seems not yet ripe for such a change; the genera, if these exist, are still too undefined, the species too isolated from each other. Mohs gave a similar nomenclature in German, which was translated into English by Haidinger, and adopted with modifications by Professor Jameson. It has reference, however, only to his system; and even some who retain this have, like Haidinger, returned to a more

* The adoption of this view of the nature of silica, that it contains only two atoms oxygen, SiO^2, is recommended by the great simplicity which it gives to the composition of many important minerals. In stating the opinions of other authors, it has, however, been occasionally necessary to employ the common formula for silica, or SiO^3.

simple nomenclature. In this treatise specific names only are used, selecting as far as possible the oldest, best known, and most common. Some of these are, however, objectionable, and have been placed among the synomyms, whilst a less current term is put in the first place. We have considered it a valid objection to a specific name, that it contains a description which is either inaccurate or not characteristic. Thus names like white cobalt, grey copper, magnetic iron, and many others, must be rejected, the colour being either variable or not peculiar, and other ores of iron being magnetic as well as the proto-peroxide. Chemical names are also inappropriate, as they belong to a different science, in which they designate a definite compound, which is not the case in mineralogy. As just stated, the chemical composition of minerals is rarely pure, and one isomorphous element may replace another to a considerable extent without destroying the identity of the species, which in chemistry is not true. The same chemical substance also occasionally forms two minerals, and the chemical name, equally applicable to both, cannot rightly be appropriated to one. In selecting new names for such species, those used by Haidinger in his Determinative Mineralogy have generally been preferred. As the common synonyms are given at the same time, it is believed no difficulty will be occasioned by these changes.

PART II.

DESCRIPTION OF MINERAL SPECIES.

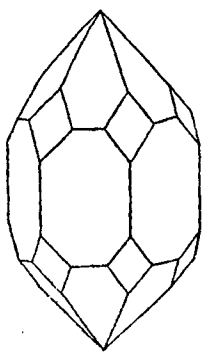
I. ORDER.—THE OXIDIZED STONES.

I. FAMILY.—QUARTZ.

1. *Species.*—QUARTZ. Quarz, *Werner*, *Hauy*, &c. Rhombohedral Quartz, *Mohs.*

Hexagonal; in common quartz apparently holohedric, but the purest varieties or rock crystal show decided tetartohedral forms (see above, p. 23). The primary pyramid P, has the middle edge = 103° 34′, and the polar edges = 133° 44′, and is often perfect. Very frequently, however, it appears as a rhombohedron R (or rather $\frac{1}{4}$P), with polar edges = 94° 15′. Very common forms are ∞P, 3P, 4P, 11P, with the trigonal pyramids 2P2, and many varieties of trigonal trapezohedrons $m\mathrm{P}\frac{m}{m-1}$, the usual one being $6\mathrm{P}\frac{6}{5}$. The two latter forms are always subordinate, whilst the others with R generally determine the character of the crystals, which consequently appear either prismatic, or pyramidal, or rhombohedric. Among the more common combinations are the prism terminated by the pyramid or ∞P . P; ∞P . P . 4P, the forms ∞P and 4P being combined in an oscillatory manner, producing striæ on the face of the prism; ∞P . P . $\frac{1}{4}$(2P2), (fig. 105,) the last face appearing as a rhomb replacing the angles between the two other forms; and also ∞P . P . $\frac{1}{4}$2P2 . $\frac{1}{4}$ $(6\mathrm{P}\frac{6}{5})$, the last face again forming a trapezium between the rhomb and the faces of the prism. In all these combinations, P is frequently divided into R and —R, the latter very often entirely wanting; and a rhombohedric character is thus im-

Fig. 105.



parted to the crystals, even when composed predominantly of other forms. As stated, the faces of the prism ∞P are frequently striated horizontally; those of R are often smoother and more shining than those of —R.

Twins or macles are common, the axes of the two crystals being parallel, so that the +R faces of the one are parallel to the —R faces of the other. Sometimes the crystals are merely in juxtaposition (fig. 84 above), at other times they interpenetrate so as to form apparently only a single crystal. The crystals occur either single, attached, or imbedded, or several combined in groups and druses. Fibrous or columnar masses terminating outwards in free crystals are very common. Most frequently it is found granular, massive, or compact; also in pseudomorphs, in petrifactions, and various other forms. The cleavage (best obtained by heating the specimen, and then cooling it suddenly in water) is rhombohedric along or parallel to R, but very imperfect; or prismatic along ∞P, but still more imperfect. The fracture is conchoidal, uneven, or splintery, H = 7; G = 2·5 — 2·8, or 2·65 in the purest varieties.

Quartz is properly colourless, but more often coloured in various shades of white, grey, yellow, brown, red, blue, green, or even black. Lustre vitreous, inclining to resinous on the fracture surfaces and in some varieties.—It is transparent or translucent, sometimes almost opaque.—Exhibits double refraction and circular polarization.—B.B. is infusible alone; with soda effervesces and melts into a clear glass. —Insoluble in acids, except the fluoric.—When pulverised, slightly soluble in solution of potash. Chem. com. $Si O^2$, or $Si O^3$, with 48·04 silicium and 51·96 oxygen, but frequently contains a small amount of the oxides of iron or titanium, of lime, alumina, and other substances. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Manganese perox.	Total.	
1	97·50	0·25	0·50	...	0·25	98·50	Rose.
2	95·00	1·75	0·25	1·50	...	98·50	Klaproth.
3	94·50	2·00	0·25	1·50	...	98·25	Do.
4	98·5	0·5	1·0	...	...	100·	Bucholz.
5	95·25	0·41	2·66*a*	1·00	magnesia, 0·67	99·09	Beudant.
6	94·84	0·47	3·64*a*	...	water, 1·05	100·00	Do.

(*a*) Protoxide.

Many varieties of quartz have been distinguished by particular names. Thus the highly transparent colourless varieties are named rock-crystal, of which the finest specimens occur in druses in the mica slate and other rocks of Dauphiné, Switzerland, and Tyrol, in some

parts of the Pyrenees, in Hungary, in Siberia, Brazil, Madagascar, and Ceylon. Fine, but smaller, crystals are found at Cape Diamond near Quebec, in the marble of Carrara, and in the keuper marls of Lippe. The Amethyst includes the violet-blue varieties, generally in thick columnar masses crystallized as pyramids on the exterior. The planes of union of the prismatic portions are often marked by zig-zag or undulating lines, and the colour is disposed similarly or in clouds, and all specimens showing this peculiar arrangement are now classed as amethyst. The blue colour seems to be caused by peroxide of iron. Heintz found a very dark Brazilian amethyst become colourless at 250° (cent.?) and it contained at most 0·01 per cent. manganese, which could not be the cause of the colour. A lighter specimen from Brazil yielded 0·0197 iron peroxide, 0·0236 lime, 0·0133 magnesia, and 0·0418 soda. Another gave only 0·00273 per cent. carbon, so that organic matter can hardly produce the colour. The finest blue amethysts come from Siberia, Persia, India, and Ceylon; white or yellow varieties (named topaz) from Brazil. Less remarkable specimens are found in Hungary and Siebenburg, and in Ireland, near Cork. The wine yellow, or citrin and gold topaz; the brown or smoky quartz; and the black or morion, are found in large crystals in Siberia, Bohemia, Pennsylvania, and other places. The Cairngorum stone from the Scottish Highlands is a brown or yellow variety. It was formerly much valued for ornamental purposes, and an Edinburgh lapidary cut nearly L.400 worth of jewellery out of a single crystal.

Less valued are—the rose-quartz of various shades of red inclining to violet blue. Some ascribe the colour to manganese, in a vein of which it occurs at Rabenstein, near Zwiesel in Bavaria; but Fuchs found 1 — 1·5 per cent. oxide of titanium in specimens from this locality; whilst Berthier says, that the colouring matter of that from Quincy is of organic nature. It is also found in Finnland, Siberia, and Connecticut. Milk quartz, milk-white and slightly opalescent, is chiefly from Greenland. Prase, leek-green, and other shades of green, often from a mixture of actinolite (see analyses 4, 5, 6 above), occurs at Breitenbrunn Saxony, Kupferberg Silesia, in the Harz, and in fine crystals on the Cedar Mountain in South Africa. Cat's eye, is greenish-white or grey, olive-green, red, brown, or yellow, and contains parallel fibres of amianthus. The finest is from Ceylon and Malabar, but also occurs at Treseburg in the Harz, Hof in Bavaria, &c. The Avanturine is yellow, red, or brown, being coloured either by scales of mica, or merely by numerous minute parallel fissures (compare oligoclase). It is found in India, in Spain, and Scotland. The Siderite is an Indigo or Berlin blue variety from Golling, in Salzburg. The fibrous quartz

in fine parallel fibres seems very common near the Orange river at the Cape.

Common quartz is the most abundant of mineral bodies occurring either crystallized or massive, disseminated or aggregated in various forms. Its usual colour is white or grey, but other tints, as red, brown, &c., are common. It is a frequent constituent in many rocks. Some varieties are so impure or intimately mixed with other minerals as to be properly rocks rather than simple minerals. Of this kind is: (1.) The Ferruginous quartz, or iron-flint (Eisenkiesel), rendered red, yellow, or brown, from the hydrated peroxide of iron and manganese. It is often found associated with iron ores, and crystallized at Sundvig, Westphalia, and Eibenstock, Saxony.

(2.) Jasper (*jaspis*, Werner; *quarz jaspe*, Hauy), coloured red by peroxide, yellow or brown by the hydrate of iron, but also exhibiting many other colours, as green, grey, white, and black, in some kinds alone, in others in spots, veins, and bands; the latter the ribbon or Egyptian jasper. This mineral is abundant in rocks of various age, and in many countries; as in Egypt, in the Ural, especially the ribbon jasper; the blood-red in the Tuscan Apennines; at Kandern in Baden; in the Harz, and in many parts of Scotland.

The following is the composition of two varieties:—

	Silica.	Iron perox.	Alumina.	Lime.	Water.	Total.	
1	95.76	2·74	1·50	...	...	100	Walchner from Kandern.
2	93·57	3·98	0·31	1·05	1·09	100	Beudant.

The porcelain jasper, produced by the action of heat on clayslate, resembles this mineral in external aspect, but is very different chemically.

(3.) Lydian stone, or flinty slate, of various black, grey, or white colours, or rarely green or brown, has a splintery or conchoidal fracture, and breaks into irregular more or less quadrangular fragments, often separated by veins of white quartz. It passes by many transitions into clay slate, and is often merely an altered portion of this rock. Two varieties gave on analysis:—

	Silica.	Alumina.	Magnesia.	Lime.	Iron protox.	Soda.	Potash.	Carbon.	Water.	Total.
1	96·50	0·60	...	0·22	0·74	...	...	0·01	1·25	99·32
2	61·24	18·75	4·91	0·05	11·70	2·59	1·22	0·49	...	100 95

The iron contained traces of protox. of manganese. No. 1 is by Du Menil; No. 2 by Schnedermann, of a specimen from Osterode in the

Harz. Lydian stone is common in many countries, sometimes forming whole beds, as in Scotland. It has long been used as a touchstone for gold, whose purity is shown by the colour of the streak; and at Elfdal is manufactured into beautiful vases and other ornaments.

(4.) Hornstone or chert is compact, with smooth conchoidal or dull splintery fracture, translucent on the edges, and of a dirty grey, red, yellow, green, or brown colour. It passes into flint, flinty slate, or common quartz, and much resembles some compact felspars; but is distinguished by its infusibility, B.B. It is common in many secondary and tertiary formations, as the mountain limestone, oolite, and greensand; and often contains petrifactions, as shells, madrepores, and wood. At Schneeberg, in Saxony, it forms pseudomorphous crystals after calc-spar. Some varieties are cut into ornamental articles, and others used for mill-stones or grinding-stones.

Another class of siliceous minerals seem intermediate between quartz and opal, or as Fuchs affirms, are an intimate mixture in indeterminate proportions of crystalline and amorphous silica, the latter separable by solution of potash. Of this nature are calcedony and flint. The latter (*Feuerstein*, Werner; *Quarz-agate pyromaque*, Hauy) occurs chiefly in the chalk formation, sometimes in beds or vertical veins, more often in irregular lumps or concretions, inclosing petrifactions, as sponges, echinites, shells or siliceous infusoria. Its colour is greyish-white, grey, or greyish-black, also yellow, red, or brown; sometimes in clouds, spots, or stripes. It is semitransparent, with a dull lustre and flat conchoidal fracture. The exterior coat is generally white, and, according to Vaquelin, contains from 10 to 5 per cent. carbonate of lime. The interior is more nearly pure silica, with about 1 per cent. of alumina and iron peroxide, and 1 or 2 per cent. water. The colour seems partly derived from carbon or organic matter. Heintz found in three varieties,

	Carbon.	Water.	
1.	0·01	1·14	From Jura formation.
2.	0·066	1·103	Light coloured from chalk, Rugen.
3.	0·073	1·298	Very dark, from do.

In a specimen from Limhamn in Schonen, Berzelius found 0·117 potash, and 0·113 of lime, with traces of iron peroxide and alumina, and a small amount of carbonaceous matter. The latter is probably derived from the siliceous infusoria and sponges, which, according to Ehrenberg, have furnished the chief part of the silica. Mr Bowerbank has also shown that almost all flints exhibit under the microscope a fibrous tissue, like that of sponges, whence he concludes that they have been formed as petrifactions of these bodies.

Flint is very abundant in the chalk formation of northern Europe; in the Apennine limestone of Italy, in Spain near Madrid and the mountains of Jaen, in Palestine and other countries. It was formerly much used for gun-flints, and now for the manufacture of glass and pottery. Savage nations fashion it into arrow-heads, knives, &c.; and it is sometimes cut into cameos or other ornaments.

Calcedony is semitransparent or translucent, of an even, conchoidal, or splintery fracture; and of various white, grey, blue, green, yellow, or brown colours. It forms stalactitic, reniform, or botryoidal masses, sometimes with a curved lamellar structure. Occasionally it appears crystallized, or forms pseudomorphs or petrifactions. It is found in beds or veins, in nests, balls, and amygdaloidal cavities, in various igneous and stratified formations. Fine varieties are found at Trevascus mine in Cornwall, in Scotland, Hungary, Tyrol, Bohemia, Bavaria (Oberstein), in the amygdaloids of Iceland and Faroe, and many other countries. At Presztyan in Siebenburg fine smalt-blue crystals occur; at Haytor in Devonshire it forms pseudomorphs after Datolite (the Haytorite); and in Cornwall pseudomorphs of fluor are common. The *Carnelian* includes chiefly the blood-red varieties, but also some yellow, brown, or almost black specimens. The finest come from India, Arabia, Surinam, and Siberia, but it also occurs in Bohemia, Saxony, and Scotland (Perthshire). In a specimen from the Gobinskoi Steppe in China, Heintz found in 100 parts, 0·081 alumina, 0·050 iron peroxide, 0·028 magnesia, 0·0043 potash, 0·075 soda, 0·003 carbon, and 0·391 water. The colouring matter seems the peroxide of iron. Those from Cambaya near Surat are originally yellow, but become red by burning, which deepens the colour, probably by producing small fissures. The *Plasma* is of a leek or grass-green colour, and waxy lustre. It is common among the ruins of Rome from some unknown locality; but is found of great beauty on Olympus, and also in the Schwarzwald near Baden, and the Hauskopf near Oppenau, and is brought from India and China. The *Chrysoprase* of apple-green tints contains, according to Klaproth, 1 per cent. nickel oxide. It is rare, but occurs at Kosemitz and other localities in Silesia, and in Vermont in North America. The *Heliotrope* is dark-green, sprinkled with deep-red spots, and hence is named bloodstone. It is found in Siberia, Bohemia, the Fassa Valley, and in the Island of Rum and other parts of Scotland. *Agates* are mixtures chiefly of calcedony in layers, with jasper, amethyst, or common quartz, and abound in the amygdaloids of our own and other countries. The colours are variously disposed, and often artificially produced. In some moss agates they are probably formed by hydrates of iron or manganese; to others an organic nature has been ascribed. The *Onyx*, with alternate lay-

ersof white, brown, or black, was much used in ancient times for cameos.

There are many other varieties of this highly-important mineral. Some crystals are remarkable for their great size, as one in the Museum at Paris, measuring 3 feet in diameter, and weighing nearly 8 cwt. Mr Allan mentions a group at Naples which weighs half a ton, and another at Milan, 3¼ feet long, and 5½ in circumference, which weighs 870 pounds. Other specimens are remarkable from enclosing various substances, some of them crystallized. Among these are silver, copper, mispikel, silver-glance, iron pyrites, pyrargyrite, antimony-glance, rutile, cassiterite (tinstone), iron-glance, pyrrhosiderite, magnetite, disthene, tremolite, amianthus, mica, chlorite, desmine, tourmaline, topaz, and calc-spar. Still more curious are the cavities containing air, water, naphtha, or other fluids. Sometimes the cavity is only partially full, and the globule moves backwards and forwards as in a spirit level. Sir D. Brewster mentions a specimen with a cavity seven-tenths of an inch long, and half full of fluid, and another from Quebec containing a group of calc-spar crystals, which move through the fluid on turning the specimen. Mr Allan "possesses a fragment of amethyst with four crystalline cavities enclosing this fluid. The largest of these is nearly half an inch in length, of which the vacuity is about one-fourth; at a temperature of 83° the fluid dilates and fills all the cavities; and as it reappears on cooling, an apparent ebullition is manifested." Sir H. Davy says the liquid is water with minute quantities of saline matter; the gas azote. R. W. Fox found in crystals from a vein in the Consolidated Mines water partly tasteless or with a little common salt; and in one crystal water very acrid, containing sulphuric acid, iron, lime, and muriatic acid, or one-tenth by weight of salts, chiefly sulphate of iron.—(Compare Le Camus, N. Mém. de Dijon, 1783, p. 21; Brewster, Ed. Roy. Soc. Trans., vol. x.; Edin. Phil. Jour., vol. ix.; Davy, Phil. Trans. for 1822; Berzelius, Jahresbericht für 1823.)

2. OPAL. Quarz résinite, *Hauy*; Uncleavable quartz, *Mohs*.

Amorphous, and without cleavage. Fracture conchoidal, or rarely even, splintery or earthy. Very brittle. H. = 5·5—6·5, G. 2—2·2. Transparent to opaque. Lustre vitreous, inclining to resinous. Colourless, but coloured white, yellow, red, brown, green, or grey. Some varieties exhibit a beautiful play of colours, which is destroyed by heat. B. B. decrepitates and becomes opaque, but is infusible; in the closed tube yields water. Almost wholly soluble in solution of potash. Chem. com. silica with 5 — 13 per cent. water; or probably

a mere hardened natural gelatine of silica with water as an accidental mixture. Analyses.

	Silica.	Watr.	Alumina.	Iron perox.	Total.	
1	90	10	...	...	100	Klaproth, Noble O., Cscherwenitza.
2	93·13	5·25	1·62	...	100	Do. Hydrophane, Hubertsburg.
3	93·50	5·00	...	1·00	99·50	Do. Yellow O., Telkebanya.
4	43·50	7·50	...	47·00	98·0	Do. Brown-Red O., do.
5	92·00	7·75	...	0·25	100	Do. Fire O., Zimapan, Mexico.
6	92·00	6·33	trace.	...	98·33	Bucholz, Hyalite, Frankfort.
7	93·00	6·13	0·13	0·38	99·65	Brandes, Wood O., Oberkassel.
8	95·5	3·0	(0·2 *a*)	0·8	99·5	Schaffgotsch, Hyalite, Waltsch Bohemia.
9	97·48	2·52	...	...	100·00	Apjohn, Hyalite, Mexico.

	Silica.	Watr.	Alumina.	Iron perox.	Potash.	Soda.	Lime.	Magnesia	Total.	
10	95·32	3·47	0·20	...	0·07	0·06	0·06	0·40	99·58	Forchhammer
11	88·73	7·97	0·99	...	0·34		0·49	1·48	100	Do.
12	82·75	10·00	3·50	3·00	...	...	0·25	...	99·50	Stucke.
13	90·20	2·73	1·86	(4·11 *b*)	0·80	0·90	(0·31 *c*)	0·86	101·76	Wrightson.
14	83·73	11·46	...	3·58	...	...	1·57	0·67	101·00	Wertheim.
15	73·45	12·89	...	9·95	...	...	1·21	2·13	99·63	Do.

(*a*) = lime; (*b*) = protox.; (*c*) = sulphuric acid.

(10.) Cacholong from Faroe; (11.) Fire Opal from do.; (12.) Semiopal from dolerite at Steinheim, near Hanau; (13.) Semiopal, Schiffenberg near Giessen; (14.) Fresh, shining; and (15.) Dull, weathered, opal from Meronitz.

Forchhammer thinks that the opal from the trap formation (10–15) must be distinguished chemically from that from the trachyte of Hungary, which is a pure hydrate of silica. Both originate from decomposition of felspar, but the former by water at a high temperature, the latter by the evolution of sulphuric acid in the trachyte, and the simultaneous formation of the alumstone. He distinguishes (1.) cacholong, very hard and with little water; (2.) trap-opal, a very acid siliceous salt; and (3.) opal of Hungary, a hydrate of silica, perhaps $\dot{S}i^3 + \dot{H}$, or $\dot{S}i^6 + \dot{H}_3$. Damour finds that opal and semiopal when heated yield water with an empyreumatic odour, and containing ammonia, probably of an organic nature. On a specimen of wood opal from Hungary I have seen a fine saline efflorescence along the pores of the woody fibre.

The chief varieties of this mineral are, (1.) Hyalite, glassy-opal, or Muller's glass, found in transparent, colourless, very glassy, small botryoidal masses or incrustations, at Frankfort-on-the-Maine, on the Kaiserstuhl in the Breisgau, Schemnitz in Hungary, Waltsch in Bohemia, in Silesia, Moravia, Mexico, and other places. Dr Apjohn has recently stated that hyalite seems to exercise the power named circular polarization, and, from the identity in optical properties with rock crystal, he thinks that it may be composed of a multitude of mi-

nute crystals of the latter mineral, thrown together without any regular or symmetrical arrangement. (2.) Fire-opal or girasol, transparent, brilliant vitreous lustre, and bright hyacinth red or yellow colour, is only found at Zimapan in Mexico, and in the Faroe islands (Nos. 5 and 11 above). (3.) Noble opal, is semitransparent or translucent, lustre resinous inclining to vitreous, bluish or yellowish-white, with brilliant prismatic colours. Brewster has shown that these are caused by minute pores in the mass, and not by cracks or fissures. It occurs in irregular masses or veins, especially at Czerwenitza near Eperies in Hungary, also at Frankfort, and at Gracios a Dios in Honduras. (4.) Common opal, semitransparent, vitreous; colour, various shades of white, yellow, green, red, or brown. Occurs chiefly in irregular masses, but also stalactitic, or as a pseudomorph after calc spar or augite. It is most common in Hungary, but also found in Faroe, Iceland, at the Giant's Causeway, and in the Western Isles of Scotland. (5.) Semiopal, similar in colour and mode of occurrence, but duller and less pellucid, is common with the last variety. The wood opal, or lithoxylon, in which the form and texture of wood are distinctly seen, is very abundant in Hungary, at Kremnitz, Libethen, and Telkobanya, and also occurs in Bohemia, in the Siebengebirge, and near Hobart's Town in Tasmania. (6.) The menilite, from Mont Menil near Paris, forms compact reniform masses, sometimes with a slaty structure, is opaque and of brown or bluish-grey colour. (7.) Opal jaspar (anal. 4) is of a blood-red, brown, or yellow colour, and spec. grav. = 2·5. (8.) Cacholong, opaque, dull, glimmering, or pearly lustre, and of yellowish or rarely reddish-white colour, occurs in veins or reniform and incrusting masses in Faroe, Iceland, and at the Giant's Causeway, and in remarkable beauty in Bucharia. The name is Mongolian, meaning "beautiful stone." It adheres strongly to the tongue; and one variety is named Hydrophane, from imbibing water, and becoming translucent when immersed. (9.) The siliceous sinter deposited from the Geyser and other hot springs near volcanoes; and the pearl sinter, encrusting volcanic tuffa at Santa Fiora in Tuscany, and common in other parts of Italy, and in Auvergne, are varieties of amorphous silica of recent origin. Their chemical composition is interesting.

	Silica.	Alumina.	Iron perox.	Magnesia.	Lime.	Potash & Soda.	Water.	Total.	
1	98·00	1·50	0·50	...	...	...	...	100	Klaproth.
2	94·01	1·70	...	...	...	...	4·10	99·81	Kersten.
3	84·43	3·07	1·91	1·06	0·70	0·92	7·88	99·97	Forchhammer.
4	93·25	2·00	1·25	...	...	...	3·00	99·50	Zellner.
5	94·0	2·0	...	...	4·0	...	...	100	Santi.

Nos. 1, 2, 3, are of the deposit by the Geyser in Iceland; No. 4 from Kohlen in Saxony; No. 5 the pearl sinter of Santa Fiora; in which, however, Klaproth found 12 per cent. water, 5 alumina, and 3 iron peroxide Hochstetter, in the sinter of a well in Flores in the Azores, found 13 per cent. soluble in dilute acid, containing iron peroxide, alumina, and lime: the remainder consisted of 67·6 silica, 21·0 iron peroxide, 10·2 alumina, and 1·0 lime. Other deposits from the Furnas on Terceira consisted partly of iron peroxide, with a little silica and alumina, partly of sulphur 22·2, silica 77·05, and iron peroxide 1·07. In the Michaelite from St Michael in the same islands Webster found 83·65 silica, and 16·35 water.

EARTHY SILICA.

Of this substance there are many varieties, but they are rather rocks or organic remains than minerals.

(*a.*) *Spongiform quartz*, Phillips; *Schwimmstein*, Werner; *Quartz nectique*, Hauy, is of a coarse earthy aspect, soft and often friable, and of a yellow or greyish-white colour. It is porous, and swims on water till saturated. It occurs in great abundance at St Ouen near Paris, and, according to Ehrenberg, consists chiefly of the siliceous coverings of infusoria. A specimen analysed by Count Schaffgotsch contained 85·9 silica, 0·7 alumina, 9·1 carbonate of lime, and 3·3 water.

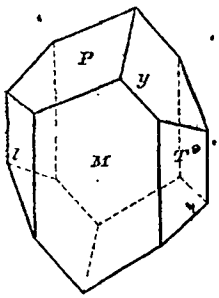
(*b.*) *Tripoli* (*Tripel*, Werner), coarse or fine earthy, and white, grey, or yellow, occurs in large masses near Tripoli in Africa, in Corfu, in Bohemia, Saxony, and Bavaria. (*c.*) *Polishing slate* (*Polirschiefer*), of a white or yellow colour, a slaty texture, opaque, brittle, and swims on water, is similar. It occurs abundantly at Bilin in Bohemia, and also consists of the siliceous bucklers of minute animals. (*d.*) The *adhesive slate* (*Klebschiefer*), from Montmartre near Paris; and (*e.*) The *mountain meal* (*Bergmehl*, and *Kieselguhr*), snow-white, pearly-grey, or greenish, have a similar origin. The latter forms beds below the soil at Santa Fiora in Tuscany, and at Oberohe in Hanover, where it is sometimes 30 feet thick below peat. It also occurs at Kymmenegard in Sweden, where it is sometimes used as food, near Berlin, in Bohemia, and the Isle of France.

II. Family.—Felspar.

3. Orthoclase, *Breithaupt;* Felspar, *Phillips;* Prismatic Felspar, *Jameson* in part; Orthotomous Felspar, *Mohs.*

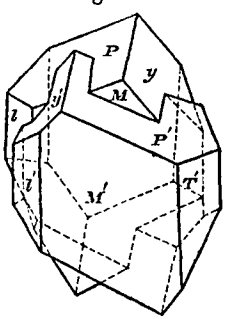
Monoclinohedric; C = 65° 47′, ∞P 118° 50′, P∞ 63° 53′, (2P∞) 90°, 2P∞ 35° 12′. Some of the most common combinations are

Fig. 106.



∞P . $0P$. $P\infty$; $(\infty P\infty)$ *(M)* . ∞P (*T*, l). $0P$ *(P)* . $2P\infty$ *(y)* fig. 106, and $0P$. $(\infty P\infty)$. ∞P . $2P\infty$. $(2P\infty)$. The crystals appear either as short rhombic prisms when ∞P predominates; or tabular when $(\infty P\infty)$; or short hexagonal prismatic when ∞P and $(\infty P\infty)$; or rectangular prismatic when $0P$ and $(\infty P\infty)$ predominate. Macles are frequent, especially (1.) with the twin axis parallel to the chief axis, or (2.) with it perpendicular to a face of $(2P\infty)$, but other laws occur and sometimes several are seen in one group. The first law is common in crystals from Carlsbad and Elnbogen in Bohemia; the crystals often partially interpenetrating as in fig. 107; the second law is seen in those from Baveno.

Fig. 107.



Orthoclase occurs either in crystals disseminated singly, or attached and combined in druses, or massive in coarse and fine granular aggregates. Cleavage basal, along *P*, very perfect; clinodiagonal, along *M*, perfect; and hemiprismatic parallel to one face of ∞P in traces. Fracture conchoidal or uneven and splintery; H. = 6; G. = 2·53—2·58. Transparent to translucent on the edges. Lustre vitreous, but often pearly on the more perfect cleavage planes; and also opalescent, with bluish or changing colours, especially on the faces of $\infty P\infty$. Colourless, but generally coloured in various shades of red, yellow, grey, or green. B.B. fuses with difficulty to an opaque vesicular glass; and with salt of phosphorus leaves silica. Solution of cobalt colours the fused edges blue. Not affected by acids. Chem. com. $\dot{A}i\,\dot{S}i^3 + \dot{K}\,\dot{S}i^3$ with 65·4 silica, 18 alumina, and 16·6 potash, the latter including a little soda and lime. Analyses *(Table on next page)*.

According to Abich all orthoclase from trachyte contains soda along with the potash; C. Gmelin states the same of that from the phonolite, and in Nos. 21, 22, the soda even predominates, as in albite. Hence Abich infers, that potash and soda must not only be isomorphous, but also dimorphous. Berthier finds, that when equal portions of orthoclase and carbonate of lime are fused together in a high temperature nearly two-thirds of the potash volatilizes.

The following varieties are distinguished:—

(1.) Adularia and ice-spar, including the transparent or translucent

	Silica.	Alumina.	Potash.	Soda.	Lime.	Magnesia.	Iron perox	Watr.	Total.	
1	64	20	14	..	2	...	...	...	100	Vauquelin.
2	65	20	12·25	...	trace.	...	1·25	0·50	99·00	Klaproth.
3	65·69	17·97	13·99	1·01	1·34	...	trace.	...	100	Abich.
4	66·75	17·50	12·00	...	1·25	...	0·75	...	98·25	V. Rose.
5	64·50	19·75	11·50	...	trace.	...	1·75	0·75	98·25	Klaproth.
6	65·72	18·57	14·02	1·25	0·34	0·10	...	...	100	Abich.
7	65·32	17·89	13·05	2·81	0·10	0·09	0·30*a*	...	99·75	Do.
8	65·91	20·93	10·18	3·50	0·11	...	...	...	100·63	Moss & Litton.
9	65 82	19·00	12·25	3·30	0·34	0·07	...	...	100·78	Do.
10	66·43	17·03	13·96	0·91	1·03	...	0·49	...	99·85	Kröner.
11	65·52	17·61	12·98	1·70	0 94	...	0·80	...	99·55	Kersten.
12	68	15	14·50	...	...	...	0·50	...	98·00	Klaproth.
13	66·6	18·5	8·0	4·0	1·0	...	0·6	...	98·7	Berthier.
14	70·00	16·50	11·50	...	...	...	0·25	...	98·25	Klaproth.
15	65·52	19·15	14·74 *b*	...	0 60	...	...	...	100	G. Rose.
16	66 1	19·8	6·9	3·7	...	2·0	...	...	98·5	Berthier.
17	66·73	17·36	8·27	4·10	1·23	1·20	0·81	...	99·00	Abich.
18	65·00 *c*	18·64	9·12	3·49	1·23	1·03	0·83*d*	...	99·49	Do.
19	67·07	15·72	6·68	2·86	3·16	1·40	2·41	...	100·10	Do.
20	64·86	21·46	2·62	10·29	trace.	trace.	trace.	...	99·23	Schnederman.
21	64·86	21·92	4·15	7·53	trace.	trace.	...	...	98·46	Do.
22	66·82	17·58	14·80	...	...	...	0.09	...	99·29	Plattner.
23	65·76	18·31	14·66	...	1·20	...	trace.	...	99·33	Evreinoff.
24	68·6	16·6	14·8	...	...	...	...	...	100	R. Phillips.
25	67·90	18·00	7·50	...	1·00	3·25	2·70	1·00	101·35	Thomson.

(*a*) With copper oxide, + 0·19 manganese porox; (*b*) with a little soda and loss; (*c*) + trace of titanic acid; (*d*) + 0·13 manganese perox.

Nos. 1, 2, 3, are the adularia variety, from (2) Friedrichsvärn, Norway; (3) St Gotthardt. Nos. 4–11, common orthoclase or felspar. (4) flesh-coloured from Lomnitz; (5) near Carlsbad; (6) Baveno; (7) Siberia, (the amazon-stone); (8) Alabaschka; (9) Schaitansk; (10) flesh-red from veins of tin ore near Marienberg, G = 2·44; (11) gneiss at Freiberg. Nos. 12–21 glassy felspar or sanidine from (12, 13) Drachenfels, Rhine; (14) the peperino near Rome; (15) Vesuvius; (16) Mont d' Or; (17) Epomeo Ischia; (18) Arso Ischia; (19) tufa of Pausilipo; (20, 21) basalt of the Hohen-Hagen between Gottingen and Münden. No. 22, Valencianite; (23) mikrokline from Arendal; (24) Murchisonite, Dawlish; (25) erythrite, Kilpatrick Hills, Glasgow.

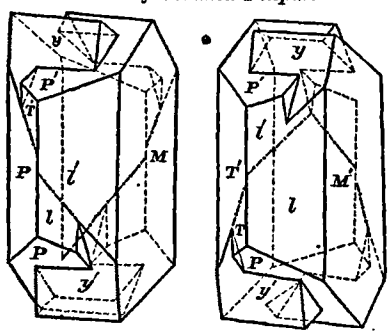
varieties, with splendent lustre, and either colourless and white, or only slightly-tinged grey, green, yellow, red, or brown. Some with a bluish opalescence are named *moonstone*. It sometimes occurs as a constituent of granite, syenite, and gneiss; but more common in veins and druses in similar rocks near St Gotthardt, in Mont Blanc, Dauphiné, and at Arendal. Beautiful specimens with changing colours occur in Ceylon, in the zircon-syenite of Norway, the Microcline of Breithaupt, and in Greenland. The Valencianite of Breithaupt from Valenciana in Mexico seems only adularia.

(2.) Common felspar is less splendent and transparent, and generally white or red, especially flesh-red in colour. The Amazonstone is a verdigris-green variety (anal. 7), from Lake Ilmen in the Ural, near Miask, coloured by copper oxide. Felspar is a very common constituent of many rocks. Fine attached crystals are found at Baveno on Lago Maggiore, at Lomnitz in Silesia, in many parts of the Ural, in Ireland, and in Aberdeenshire Scotland. Imbedded crystals of great beauty occur at Carlsbad and Elnbogen, Bohemia, in

the Fichtelgebirge, and in Brazil. The Murchisonite of Levy, characterised by a golden or greyish-yellow tint, from the granite of Arran and from Dawlish (anal. 24), seems a mere variety, and Thomson's Erythrite (anal. 25) is also scarcely distinct.

Fig. 108.

Macles of Common Felspar.



(3.) The glassy felspar or sanadine is by some considered a distinct species, characterised by the presence of four per cent. or more of soda; and also differing slightly in angular measurement ($C = 63°$ 55′, ∞P 119° 13′); but the forms and combinations are nearly the same with those of orthoclase. The crystals are imbedded, greyish or yellowish white, or grey; vitreous lustre; transparent or translucent, and often much cracked or fissured. It seems to characterise the volcanic and similar igneous rocks, as trachyte, pitch-stone, pearl-stone, and obsidian, whilst the adularia and common felspar are found in the plutonic and metamorphic rocks. Very fine crystals occur in the trachyte at Drachenfels on the Rhine, at Mont d'Or and other parts of Auvergne, in Mexico, and Chili; and of less beauty in that of Hungary, Milo, and the Euganean hills. It is found in trachytic lavas in Italy at Montamiato, Pozzuolo, Ischia, &c., in Iceland, and other countries. In the basalt of the Hohenhagen near Göttingen, it seems to have been originally common felspar but altered by heat,—a change seen in the walls of some furnaces formed of eurite-porphyry. It is common in the ejected blocks on Vesuvius with hornblende, and at Lake Laach. Also, it is said, in Arran, Rum, and other parts of Scotland.

Orthoclase has been known to form artificially, as in the copper furnaces of Mansfeld, where, besides silica, alumina, and potash, it contains traces of peroxide of manganese and lime. It has also been found in the iron furnaces at Stolberg in the Harz, by the younger Hausmann, in small single or macled crystals, like adularia.

Orthoclase is one of the most important constituents of the crust of the globe, occurring not only in granite, gneiss, and porphyry, but in many secondary formations composed of their debris, as in greywacke, and some sandstones and conglomerates. In rocks it is very commonly associated with quartz, sometimes as a mere granular mixture; at others, as in the graphic granite of Portsoy and Aberdeen-

shire, regularly combined. In Bennachie the crystals of orthoclase contain imbedded grains of quartz. Mica and chlorite also commonly accompany it; and large crystals of orthoclase are often covered with small ones of albite.

This mineral is very liable to decomposition, when it is converted especially into kaolin. It first loses its lustre and transparency, becomes paler in colour, whilst its hardness and gravity diminish, and at length falls down into a white earth. In this process the potash forms with four atoms silica ($\ddot{K}\ddot{S}i$) a soluble silicate, which is removed, and leaves $\ddot{A}i\ \ddot{S}i^2$ in combination with two atoms water. In this manner the rocks containing it are destroyed, a loose soil formed, and the alkali essential to the life of plants brought within their reach. The kaolin is used for manufacturing porcelain and stoneware. Some felspars are cut as ornamental stones, as the adularia or moonstone, and the green amazon stone.

Compact Felspar or *Feldstein* seems generally a mixture of orthoclase and quartz. It is often harder than the pure mineral, with G. = 2·59 — 3. Its colour is white, grey, red, or yellow, sometimes in spots or bands. The softer varieties are named claystone, and often show bluish or purplish tints, with G. = 2·21. B.B. most of them melt with difficulty to a white enamel, when the small grains of quartz often appear. This distinguishes it from hornstone, which is infusible. It is a common constituent in the porphyry rocks of many countries, as of the Cheviots, Pentland, and Ochil hills in Scotland. Sweden also contains many varieties, of which the leelite from Grythyttan has been made a separate species, but is a distinct mixture of very uncertain composition. Analyses.

	Silica.	Alumina.	Potash.	Lime.	Magnesia.	Iron perox.	Watr.	Total.	
1	75·20	15·00	3·40	1·20	2·40	...	1·50	98·70	Berthier, Nantes.
2	71·17	13·60	3·19	0·40	0·10*a*	1·40	3·50	93·36	Mackenzie.
3	79·00	11·50	6 60	...	...	1·25	1·00	99·75	Klaproth.
4	80·00	12·00	5·00	...	..	1·50	0·50	90·00	Do.
5	73·50	15·00	6·50	1·00	traces	1·50	0·75	99·25	Do.
6	81·91	6·55	8·88	...	...	6·42*b*	...	103·76	Thomson.
7	75·0	22·0	...	...	2·5 *a*	...	0·5	100	Clarke.
8	76·45	14·88	6·60	...	...	0·90*c*	0·93	99·76	Schafhäutl.

(*a*) = Manganese perox.; (*b*) = iron protox.; (*c*) perox. of iron and manganese.

From (1) Nantes; (2) Pentland Hills; (3, 4, 5, Weisstein) (3) Pacheralp; (4) Schemnitz; (5) Reichenstein; (6, 7) Leelite Grythyttan; (8) Claystone.

(4.) RYACOLITE, *G. Rose.* Empyrodoxer Feldspath, *Mohs;* Ice-spar in part.

Monoclinohedric; C = 63° 54′, ∞P 119° 21′, P∞ 65° 37′ (2P∞), 90° 32′; usual combination, (∞P∞). ∞P. (∞P3). 0P. 2P∞. (2P∞); the crystals are thick tabular, or short prismatic, and either dissemi-

nated singly or united in small druses. Macles occur with the twin axes parallel to the chief axis, and united by a face of (∞P∞); and also united by (2P∞), forming four-sided prisms. Cleavage basal and clinodiagonal; both almost equally perfect, H.=6; G.=2·57 — 2·58 (to 2·618, G. Rose). Transparent or translucent; lustre vitreous; colour white or grey. B. B. melts easier than orthoclase, tinging the flame yellow. Imperfectly soluble in muriatic acid, leaving silica in powder.—Chem. com. $\ddot{A}l\,\ddot{S}i^2 + \dot{R}\cdot\ddot{S}i^2$ and hence analogous to that of labradorite. Analysis.

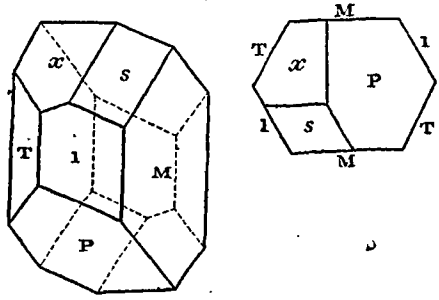
	Silica.	Alumina.	Soda	Potash.	Lime	Magnesia.	Iron perox.	Total.	
1	50·31	29·44	10·56	5·92	1·07	0·23	0·28	97·81	G. Rose.

Found with augite, mica, and nepheline in ejected blocks on Vesuvius (anal. 1), and near Lake Laach. Many so-called glassy felspars probably belong to this species.

5. ALBITE, *Eggertz, G. Rose, Phillips, &c.;* Schorl blanc, *Romé de l'Isle.* Cleavelandite, *Brooke;* Tetartoprismatic Felspar, *Mohs.* Pericline, *v. Leonhard, Phillips, &c.;* Heterotomous Felspar, *Mohs.*

Triclinohedric; 0P (*P*) to $\infty\breve{P}\infty$ (*M*) = 86° 40′, ∞P′ (*l*) to ∞'P (*T*) = 121° 38′. The crystals have a general resemblance to those of orthoclase, and many of the forms differ but very little. They are usually tabular when $\infty\breve{P}\infty$, or prismatic when $\infty\breve{P}\infty$, and 0P predominate (fig. 109). Macles are very common according to several laws, especially united by a face of $\infty\breve{P}\infty$, (fig. 110), the re-entering angle between the faces of 0P (*P* and *P*′ = 173° 20′) being very characteristic of triclinohedric felspars. Another macle common in the pericline variety is represensed in fig. 111, (compare p. 44 above). These macles are often repeated, forming polysynthetic crystals; or two macles are united according to the same law as the Carlsbad macles of orthoclase (No. 1 above). Also found massive and in granular foliated or radiating aggregates. Cleavage basal and brachydiagonal, almost

Fig. 109.



equally perfect; prismatic along ∞P imperfect. Fracture conchoidal

Fig. 110.

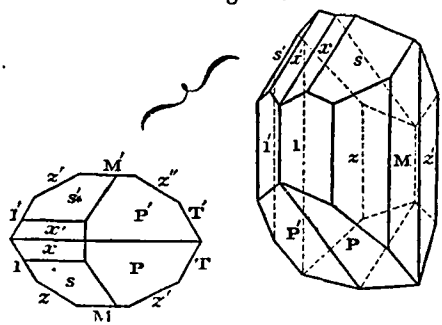
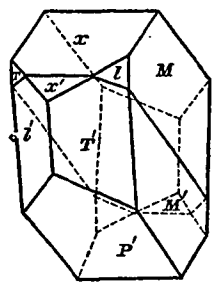


Fig. 111.



or uneven, H. = 6 — 6·5; G. = 2·6 — 2·67. Rarely transparent in small crystals, usually translucent or only on the edges. Lustre vitreous, inclining to pearly on the cleavage planes, especially 0P. Colourless, but generally white, grey, green, red, or yellow. Streak white. B.B. difficultly fusible, tinging the flame yellow, to a white semiopaque glass. Not affected by acids. Chem. com. $\dot{A}l\,\dot{S}i^3 + \dot{N}a\,\dot{S}^3$ with 69·3 silica, 19·1 alumina, and 11·6 soda, part of the last often replaced by lime or potash.

	Silica.	Alumina.	Soda.	Potash.	Lime.	Magnesia.	Iron perox.	Manga. perox.	Total.	
1	70·48	18·45	10·50	...	0·55	...	...	...	99.98	Eggertz.
2	67·75	18·65	10·06	...	...	0·34	0·95	0·25	99·00	Ficinus.
3	70·68	19.80	9·06	...	0·23	...	0·11	...	99·88	Stromeyer.
4	68·46	19·30	9·12	...	0·68	trace	0·28	...	97·84	G. Rose.
5	68·45	18·71	11·24	0·65	0·50	0·18	0·27	trace *a*	100	Abich.
6	69·11	19·34	10·98	0·65	trace	trace	0·62	trace *a*	100·70	Erdmann.
7	68·75	18·70	10·90	1·21	0·39	0·09	0·90	...	100·94	Lohmeyer.
8	67·39	19·24	6·23	6·77	0·31	0·61	...	...	100·55	Brooks (m. of 2).
9	66·11	18·96	9·24	0·57	3·72	0·16	0·34	...	99·10	Scheidhauer (m. of 4).
10	67·92	18·50	8·91	2·55	0·85	0 42	0·50	...	98·75	Kersten.
11	67·94	18·93	9·99	2·41	0·15	...	0·48*a*	(0·36)*b*	100·26	C. Gmelin.
12	69·00	19·43	11·47	...	0·20	...	...	...	100·10	Thaulow.
13	68·23	18·30	7·99	2·53	1·26	0·51	1·01	...	99·83	Abich.
14	70·22	17·29	5·62	3·71	2·09	0·41	0·82	...	100·15	Do.
15	71·60	14·75	10·06	0·32	1·06	trace	1·41	trace *a*	99·20	Schnedermann.

(*a*) Protoxide; (*b*) loss by heat.

Nos. 1–10, albite; 11–13, pericline. From (1) Finbo; (2) Pennig, Saxony; (3) Chesterfield North America; (4) Arendal; (5) Miask in greenstone, G. = 2·624; (6) Brevig, Norway; (7) Riesengebirge from granite veins in oligoclase-granite, G. = 2·624; (8) St Gotthardt, snow-white, mean of two, but perhaps mixture with orthoclase; (9) Snarum, Norway, white crystallized, mean of four analyses; (10) Deep Fürstenstolle Freiberg; (11) Zöblitz, compact pericline; (12) St Gotthardt, crystallized; (13) Pantellaria in trachyte, G. = 2·595. 14, Basis of Drachenfels' trachyte, portion insoluble in acids. 15, Adinole from Lerbach.

The above analyses show that there is no essential chemical distinction between albite and orthoclase, soda and potash being found in both, only in general in somewhat different proportions. As stated

above, their crystalline forms also resemble, and the angles of albite sometimes vary, so as to approach more closely to those of orthoclase. On this ground Breithaupt and Mohs have separated pericline from albite, making the inclination of $P : M = 86° 41'$, and $l : T = 120° 37'$,—differences from the above such as may occur in the same species, especially as the angles are not readily measured.

The chemical composition shows no distinction, and the specific gravity (= 2·54 — 2·595) is less characteristic than was imagined.

Albite is less common than orthoclase; but is a constituent of many greenstones (as near Edinburgh), and sometimes of granite, syenite, gneiss, porphyry and trachyte, or occurs in beds and veins in these rocks. Fine crystals are found at Barèges in the Pyrenees, Bourg d'Oisans Dauphiné, St Gotthardt, in the Tyrol, Salzburg, and in Norway at Arendal. Small crystals occur in the Harz, and fine massive varieties at Pennig and Zöblitz in Saxony, Finbo near Fahlun, Haddam Connecticut, and Chesterfield Massachusetts.

Adinole of Beudant is merely a compact mixture of albite and quartz of various dirty white, grey, or red colours. It is found at Sala in Sweden, Lerbach in the Harz, and other places. In aspect and mode of occurrence it resembles compact felspar.

6. Andesin, *Abich.*

Triclinohedric; forms of crystals similar to albite, but the cleavage less distinct; G. = 2·7328. Colour and other physical properties like albite. B.B. more easily fusible (like oligoclase) to a milky somewhat porous glass. Chem. com. $\ddot{A}\ddot{i}\,\ddot{S}i^2 + \dot{R}\,\ddot{S}i^2$; where $\dot{R}$ is nearly one-half soda and one-half lime. Analysis.

	Silica.	Alumina.	Soda.	Potash.	Lime.	Magnesia.	Iron perox	Total.	
1	59·60	24·28	6·53	1·08	5·77	1·08	1·58	99·92	Abich.
2	56·72	26·52	6·19	0·80	9·38	...	0·70	100·31	Francis.

A component with hornblende of the andesite, or diorite porphyry of the Cordilleras, and formerly considered an albite. No. 2 is an albite-like mineral (G. = 2·64) from Pisoje, near Popayan in Columbia, which is associated with hornblende and quartz. The proportion of silica is, however, still smaller than in andesin.

7. Saccharite, *Glocker.*

Compact, or in fine granular masses, with traces of cleavage, at least in one direction. Very fragile; fracture splintery, uneven; H. = 5 — 6; G. = 2·66 — 2·69. Translucent on the edges. Lustre vitreous, inclining to pearly or dull. Colour white, greenish-white,

or apple-green. B. B. becomes greyish-white and opaque, but melts only on thin edges. In borax forms a clear glass. Imperfectly soluble in acids. Chem. com. exactly that of andesin, except the water, which is perhaps incidental. Analysis.

Silica.	Alumina.	Iron perox.	Nickel oxide.	Lime.	Magnesia.	Potash.	Soda.	Water.	Total.	
58·93	23·50	1·27	0·39	5·67	0·56	0·05	7·42	2·21	100·0	Schmidt.

Saccharite is found in veins in serpentine in the chrysoprase mines near Frankenstein in Silesia.

8. LABRADORITE, *Beudant, Phillips;* Labrador, *Werner;* Feldspath opalin, *Hauy;* Polychromatic felspar, *Mohs.*

Triclinohedric, but dimensions unknown; 0P : $\infty\breve{P}\infty$ = 86° 30′ (or 85° 32′, according to Nordenskiold). Occurs in disseminated crystals, or massive and granular, forming polysynthetic macles like those of the pericline albite. Cleavage basal, very perfect, brachydiagonal less so; and the planes of both usually striated; H. = 6 . G = 2·68 — 2·74. Translucent, or only on the edges. Lustre vitreous, on the cleavage planes pearly or resinous. Colour grey, passing into white, green, yellow, or red. The faces of $\infty\breve{P}\infty$ often exhibit very beautiful changing colours,—blue, green, yellow, red, or brown—sometimes in bands intersecting at certain angles. B. B. fuses more readily than orthoclase to a compact colourless glass. Soluble when pulverized in muriatic acid. Chem. com. $\ddot{A}i\,\dot{S}i^2 + \dot{R}\,\dot{S}i$, consequently analogous to ryacolite, but with $\dot{R}$ chiefly $(\frac{2}{3})$-lime and $(\frac{1}{3})$ soda. Hence = 53·7 silica, 29·7 alumina, 12·1 lime, and 4·5 soda.

	Silica.	Alumina.	Iron perox.	Lime.	Magnesia.	Soda.	Potash.	Water.	Total.	
1	55·75	26·50	1·25	11·00	...	4·00	...	0·50	99·00	Klaproth.
2	54·67	27·89	0·31	10·60	0·18	5·05	0·49	...	99·19	Le Hunte.
3	52·34	29·97	0·87	12·10	...	3·97	0·30	...	99·55	Do.
4	47 9	34·0	2·4	9·5	0·2	5·1	0·9	...	100	Laurent.
5	53·48	26·46	1·60	9·49	1·74	4·10	0·22	0·42 *a*	98·40	Abich.
6	55·49	26·83	1·60	10·93	0·15	3·96	0·36	0·51	99·83	Segeth.
7	52·15	26·82	1·29	9·15	1·02	4·64	1·79	1·75	98·60	Svanberg.
8	52·52	30·03	1·72	12·58	0·19	4·51	...	...	101·55	Forchhammer.
9	52·30	29·00	1·95	11·69	0·15	4·01	0·50	...	99·60	Kerstch.
10	52·45	29·85	1·00	11·70	0·16	3·90	0·60	...	99·66	Do.
11	52·20	29·05	0·80	12·10	0·13	4·70		...	98·98	Do.
12	54·13	29·23	...	15·46	...	...	...	1·07	99·88	Nordenskiold.
13	50·58	27·60	0·10 *b*	10·27	3·73	2·97	1·27	1·73 *c*	99·12	Bergemann.
14	54.8	28·4	4·0 *d*	12·4	...	...	...	0·6	100·2	Thomson.

(*a*) + 0·89 mang. prot.; (*b*) iron prot. + 0·87 mang. perox.; (*c*) loss by heat; (*d*) protox. Nos 1–11, Labradorite, from—(1) St Paul's island, Labrador; (2) greenstone porphyry, Campsie; (3) Milngavie, near Glasgow; (4) lava, Vesuvius (white); (5) lava, Etna (crystallized); (6) Kijew; (7) hornblende rock, Tuna, Dalarne; (8) dolerite porphyry, Faroe, G. = 2·67; (9) Egursund, Norway, brown, massive, G. = 2·71; (10) do., with blue opalescence, G. = 2·72; (11) do., violet-grey lively opalescence, G. = 2·705.

Labradorite is a common constituent of many rocks, especially with augite, diallage, and hypersthene, as in dolerite greenstone, the gabbro, and hypersthene rocks. It also occurs in meteoric stones. The changing coloured variety is chiefly found in hypersthene rocks, as in Labrador and Finland. Bonsdorff ascribes this property to an excess of silica probably as quartz, and says these varieties contain 57 per cent. or more silica, the others only 52; but this is not confirmed by the analyses. Breithaupt says they differ in spec. gravity; and Haidinger affirms that the play of colour proceeds from certain regularly-defined points.

The *Scolexerose*, Beudant (anal. 12), or anhydrous scolezite from Pargas, Finnland, is a pure lime-labradorite. The *Glaucolite* (No. 13), from Lake Baikal, of a pale blue or greenish colour, with traces of cleavage in two directions, and G.= 2·72 — 2·9 (3·2, Fischer), does not seem distinct. Thomson's *Silicite* (No. 14) from Antrim is also perhaps a variety; and from the white colour the iron is probably the peroxide (= 4·5).

Saussurite, prismatic adiaphan-spar of Mohs, is a compact, dull, subtranslucent mineral, of a grey colour, inclining to blue, green, or red. H. = 6; G. = 2·69 — 3·4. B.B. fuses to a grey or greenish-white enamel, and is not acted on by acids. It seems merely an impure labradorite, occurring with, or in place of, this mineral in some gabbro and hypersthene rocks; as in the Alps near Geneva, in the Harz, Styria, the Apennines, and in Corsica. Analyses.

	Silica.	Alumina.	Soda.	Potash.	Lime.	Magnesia.	Iron perox.	Total.	
1	44·00	30·00	6·00	0·25	4·00	...*a*	12·50	96·80	T. Saussure.
2	49·00	24·00	5·50	...	10·50	3·75	6·50	99·25	Klaproth.
3	44·6	30·4	7·5	...	15·5	2·5	...	100·5	Boulanger.
4	43·6	32·0	...	1·6	21·0	2·4	...	100·6	Do.

(*a*) + 0·05 manganese perox.

From (1) Lake of Geneva; (2) do.; (3) Mont Genèvre; (4) Orezza valley, Corsica.

With the so-called smaragdite it forms the *Verde di Corsica duro*, used for vases, &c., and for ornamenting the St Lorenzo chapel at Florence.

9. Couzeranite, *Charpentier.*

Monoclinohedric; C = 87°, ∞P = 96°. The usual combination is ∞P . ∞P∞ . 0P, with the surface vertically striated. Cleavage clinodiagonal; fracture conchoidal or uneven. H. = 6; G. = 2·69. Opaque, vitreous, or resinous. Colour pitch-black, blackish-blue, or grey. B.B. melts to a white enamel; with salt of phosphorus to a milk-white glass. Not affected by acids. Chem. com, 2 $\dot{A}i\ \ddot{S}i^2$ +

3 $\dot{R}$ $\dot{S}i_2$, or, by Dufrenoy's analysis, 52·37 silica, 24·02 alumina, (and 3 $\dot{R}$ =) 11·85 lime, 1·40 magnesia, 5·52 potash, and 3·96 soda (= 98·55). It occurs imbedded in a limestone in les Couzerans in the Pyrenees. Von Kobell and Haidinger unite it with Labradorite.

10. ANORTHITE, *G. Rose, Phillips, &c.*; Biotina and Christianite, *Monticelli;* Anorthotomous Felspar, *Mohs.*

Triclinohedric; $0P : \infty\breve{P}\infty = 85° 48'$; $\infty P' : \infty P = 120° 30'$. The crystals resemble those albite, and form twins by the same laws, with a re-entering angle between *P* and *P'* of 188° 24'. Cleavage, basal and brachydiagonal perfect. H. = 6; G. = 2·7 — 2·76. Transparent or translucent. Lustre vitreous. Colourless or white. Streak white. B.B. fuses to a clear glass.—Soluble without gelatinizing in concentrated muriatic acid. Chem com. $\dddot{Al}\,\ddot{S}i + \dot{C}a\,\dot{S}i$, with 43·9 silica, 36·3 alumina, and 19·8 lime, with a little magnesia or soda and potash. Analyses.

	Silica.	Alumina.	Lime.	Magnesia.	Iron perox.	Potash.	Soda.	Total.	
1	44·49	34·46	15·68	5·26	0·74	...	...	100·63	G. Rose.
2	44·12	35·12	19·02	0·56	0·70	0·25	0·27	100·04	Abich.
3	43·79	35·49	18·93	0·34	0·57	0·54	0·62	100·34	Do. "
4	47·63	32·52	17·05	1·30	2·01	0·29	1·09	103·89	Forchhammer.
5	46·0	37·0	14·5	...	...	...	0·6	98·1	Reinwardt.
6	45·80	35·45	10·15	5·05	1·70*a*	1·85 *b*	...	100	Nordenskiold.
7	44·55	35·91	15·02	4·08	0.07	0·60 *c*	...	100·23	Svanberg.
8	42·00	34·00	15·00	...	3·20	1·00 *d*	3·35	98·55	Laugier.

(*a*) Protoxide; (*b*) moisture and loss; (*c*) loss by heat; (*d*) water..

Anorthite occurs in the ejected blocks on Monte Somma (anal. 1–3), chiefly in druses in dolomite, but also with augite and mica. Also in lava on Java (anal. 5, but perhaps incomplete); in Iceland at Selfjal near Lamba (anal. 4, mixed with a little augite); and at Paras in Columbia.

Amphodelite of Nordenskiold has the same composition, and in crystalline forms, cleavage, and macles, bears a close resemblance to anorthite. The angle of 0P to $\infty\breve{P}\infty = 85° 40'$, to $\infty\bar{P}\infty = 64°$, and to $2P\infty = 99°$ nearly; H. = 5·5 — 6; G. = 2·763. The colour is reddish-grey, or dirty-peach-blossom-red. It occurs at Lojo in Finland (No. 6), Tunaberg in Sweden (No. 7), and Tennant has analyzed a similar mineral, probably impure, from Bytown in Upper Canada. The *Indianite* (No. 8, red variety) comes from the Carnatic, and forms the matrix of the corundum. It is said to gelatinize with acids, and B.B. to be infusible.

11. OLIGOCLASE, *Breithaupt;* Natron-spodumen, *Berzelius;* Antitomous Felspar, *Mohs.*

Triclinohedric; 0P : $\infty\breve{P}\infty$ = 86° 45′; ∞P′ : ∞′P about 120°. The crystals, rather rare, resemble those of albite; and the macles often repeated or polysynthetic, are common in the granular masses that compose certain rocks. Cleavage, basal perfect; brachydiagonal less perfect; hemiprismatic along ∞P′ imperfect; H. = 6; G. = 2·64 — 2·66 More or less translucent. Lustre vitreous, inclining to pearly on the more perfect cleavage planes, to resinous on the others. Colour white, with a tinge of green, grey, or red. B.B. melts easier than orthoclase or albite to a clear glass. Not affected by acids. Chem. com. 2 $\dot{A}\dot{l}$ $\dot{S}i^3$ + $\dot{N}a^2$ $\dot{S}i^3$ with 63 sil., 23 al., and 14 soda; but several analyses agree better with 5 $\dot{A}\dot{l}$ $\dot{S}i^3$ + 2 $\dot{N}a^2$ $\dot{S}i^3$ = 63 sil., 24·9 al., and 12·1 soda. Analyses.

	Silica.	Alumina.	Soda.	Potash.	Lime.	Magnesia.	Iron perox.	Total.	
1	63·70	23·05	8·11	1·20	2·05	0·65	0·50	100·16	Berzelius.
2	61·55	23·80	9·67	0·38	3·18	0·80	...	99·38	Do.
3	63·51	23·09	9·37	2·19	2·44	0·77	...	101·37	Hagen.
4	61·06	19·68	7·55	3·91	2·16	1·05	4·11	99·52	Francis.
5	62·70	23·80	8·00	1·05	4·60	0·02	0·62*a*	100·79	Rosales.
6	64·25	22·24	7·98	1·06	2·57	1·14	0·54	99·76	Bodemann.
7	63·94*b*	23·71	7·66	2·17	2·52	trace	traces	100	Rammelsberg.
8	63·80	21·31	12·04	1·98	0·47	...	...	99·60	Chodnew.
9	62·17	23·48	7·24	2·42	2·83	0·24	0·51	99·69	Kersten.
10	63·20	23·50	7·42	2·22	2·42	0·25	0·31	99·32	Do.
11	62·97	22·29	8·45	3·69	2·06	0·54	...	100	Deville.
12	61·30	23·77	8·50	1·29	4·78	...	0·36	100	Scheerer.
13	61·22	23·32	2·56	trace	8 82	0·36	2·40	98·68	Forchhammer.
14	63·50	20·29	8·76	3·03	3·22	trace	0·67*c*	100·70	Plattner.

(*a*) Protoxide; (*b*) with loss; (*c*) + 1·23 fluosilic acid and water.

Nos. 1–11, Oligoclase from (1) granite, Danvikszoll, near Stockholm; (2) granite, Ytterby; (3) Arendal, crystallized; (4) augite porphyry of Ajatskaja, north of Catharinenburg; (5) Arendal, yellowish-white with pistacite; (6) granite veins in serpentine of Schaitansk Ural; (7) granite, Warmbrunn Silesia; (8) Kimito, Finnland, forming with quartz and mica the granite containing tantalite, G. = 2·63; (9) gneiss of the deep Furstenstoll Freiberg, G. = 2·63 — 2·68; (10) hornblende rock, Marienbad, Bohemia, G. = 2·63; (11) volcanic rocks of Teneriffa, G. = 2·58 — 2·59.

Oligoclase occurs in granite and gneiss when usually known from orthoclase by its colour. It is very common in some porphyries as the green porphyry of the Ural, and near Elbingerode in Harz. In the antique porphyry, Serpentino verde or lapis lacedæmonius of the Morea, it has a fine green colour, perhaps from chrome. No. 12 is the *Sunstone* or *Aventurine felspar* from Tvedestrand on the Christiana-fiord, Norway, where found in great beauty; as also at Archangel, Lake Baikal, and Ceylon. Scheerer has shown that the Norwegian variety at least belongs to this species, and that the play of colour arises from minute lamellar crystals of ironglance, imbedded in the mineral according to a certain law.

Hafnefiordite of Forchhammer found in hollows of lava at Hafnefiord in Iceland, (anal. No. 13), with G. = 2·729, seems a lime-oligoclase.

Loxoclase of Breithaupt (No. 14 above) found at Hammond, in New York, along with graphite, calc-spar, and diopside, has a monoclinohedric crystallization very near that of orthoclase, with a perfect basal and brachydiagonal, and indistinct macrodiagonal cleavage; H. = 6 nearly; G. = 2·61 — 2·62. Colour yellowish-grey or whitish. B.B. is far more difficultly fusible than oligoclase, colours the flame yellow, and is partially soluble in warm hydrochloric acid. Its composition is, however, the same with oligoclase, which must therefore be a dimorphous compound.

The above minerals were all included by the older mineralogists under the name felspar, now reserved for the family; and are indeed so closely related, that it is often difficult to distinguish the species from each other. A few general remarks may find a place here, and perhaps assist the student. In reference to the cleavage planes, suppose the crystal placed upright with the face *P*, or the clinodiagonal, to the spectator, and the more perfect cleavage planes of the prism (*T* or *l*) on his right hand. Then in orthoclase and ryacolite, the basal cleavage plane (*P*) is equally inclined to the clinodiagonal (*M*) on both sides; in albite, oligoclase, and petalite, it slopes towards the spectator's right hand, or forms an obtuse angle with *M* on that side; and in labradorite and anorthite it inclines to his left hand. Breithaupt gives this characteristic illustration: suppose a person inclosed in the crystal looking at the spectator,—then in orthoclase and ryacolite both his shoulders are of one height; in albite, oligoclase, and petalite, his left shoulder, and in labradorite and anorthite his right shoulder, is lower than the other.

Their chemical character has been fully described under each species. The numerous analyses given show decisively that, in the composition of these minerals, potash, soda, and lime, probably also magnesia, are isomorphous elements; whilst the crystallization of orthoclase, albite, and anorthite requires that soda and potash be considered dimorphous. With slight variations in chemical composition, similar variations in angular measurement seem conjoined. The specific gravity also varies inversely with the proportion of silica, or increases with the amount of lime and alumina. The most constant chemical character is the atomic proportion of $\dot{R}$ to $\ddot{R}$ as 1 : 3, whereas that of the silica increases in five steps in almost regular order.

Geologically important is the observation that potash abounds in

the more siliceous felspars found in the decided plutonic rocks (granite, &c.); whereas in the less siliceous, characteristic of the volcanic productions, it gives way to soda and lime. Thus labradorite appears to characterise the basaltic division of volcanic rocks, in which silicates of $\ddot{R}$ and bi- or tri-silicates of $\dot{R}$ prevail, and the glassy felspar, the trachytic division, in which tri-silicates of $\ddot{R}$ and $\dot{R}$ abound, thus distinguishing them from granite, of which the pure potash-felspar or orthoclase, with hornblende, quartz, and mica, is an essential and necessary constituent, whereas the glassy-felspar only occurs with mica and hornblende, sometimes only with augite. The proportion of soda in the glassy felspars appears to increase in the clinkstones (phonolites) simultaneously with their zeolitic constituents, whilst hornblende and mica diminish. According to Abich, pumice is only produced from rocks, of which glassy-felspar is an essential constituent, and all the trachyte, obsidian, and pumice which he examined contained soda in excess. This confirms the geological observation, that pumice is only formed from trachytic rocks, and not from those of a basaltic or doleritic nature. In its formation the original trachyte seems first to pass into a kind of obsidian. This geological distinction would seem to indicate that orthoclase and glassy-felspar are mineralogically different, though other facts oppose this view.

A. Erdmann gives the following distinctive marks of the four chief species of felspar as they occur in the Scandinavian granites.

1. Orthoclase or potash-felspar, G. = 2·5 — 2·6. B.B. melts to a porous or unequal glass.
2. Albite or soda-felspar, with pericline, G. = 2·59 — 2·65. B.B. melts more easily to a porous semitransparent glass.
3. Oligoclase, G. = 2·616 — 2·69, or when very calcareous even above 2·7. B.B. melts easily and quietly to a bead of glass, free from pores, and sometimes clear, sometimes opalescent, sometimes white enamelled.
4. Labradorite, G. = 2·67 — 2·73. B.B. fuses still more easily to a clear or opalescent bead. The powder soluble in hydrochloric acid.

12. PETALITE, *D'Andrada, Phillips, &c.*; Prismatic petelin-spar, *Mohs.*

Crystallization unknown, but probably mono- or triclinohedric. Only found in coarse granular aggregates. Cleavage in one direction distinct, in a second less so, and mere traces of a third; these three planes fall in one zone, and form angles with each other of 117°, 142°, and 101°. H. = 6·5; G. = 2·4 — 2·5. Greenish, greyish, or reddish-white to pale red. Streak white. Translucent. Lustre vi-

treous or pearly. B.B. melts easily into an obscure porous glass, colouring the flame red; the colour very distinct with fluor-spar and sulphate of potash. Not affected by acids. Chem. com. 4 $\ddot{A}i\ \ddot{S}i^6$ + 2 $Li\ \ddot{S}i^2$ + $\dot{N}a\ \ddot{S}i^2$ = 77·8 silica, 17·2 alumina, 2·4 lithia, and 2·6 soda. Analyses.

	Silica.	Alumina.	Lithion.	Soda.	Total.	
1	79·212	17·225	5·761	...	102·198	Arfvedson.
2	77·813	17·194	2·692	2·302	100	Hagen.
3	77·067	18·000	2·660	2·273	100	Do.

The above analyses are of the mineral from Utoe in Sudermania, where it occurs in a mixture of quartz and felspar, along with spodumene and turmaline. It is also found in granular limestone, with augite and sphene, at Bolton and Littleton in Massachusetts, and in loose blocks on Lake Ontario.

13. SPODUMENE, *D'Andrada, Werner, Phillips, &c.*; Triphane, *Hauy*; Prismatic triphane spar, *Mohs.*

Rhombic probably, but as yet only massive or foliated. Cleavage, prismatic along ∞P = 93° 30′ perfect; brachydiagonal more perfect. H. = 6·5 — 7; G. = 3·07 — 3·2. Translucent often only on the edges. Lustre vitreous, on the cleavage planes pearly. Pale greenish-grey or white to apple-green. Streak white. B.B. intumesces slightly, tinging the flame momentarily purplish-red, and fuses easily to a colourless glass. With cobalt solution becomes blue; in borax difficultly soluble. Is not affected by acids. Chem. com. $\ddot{A}i\ \ddot{S}i^3$ + $Li\ \ddot{S}i$ = 65·3 silica, 27·1 alumina, and 7·6 lithia. Analyses.

	Silica.	Alumina.	Lithia.	Soda.	Iron peroxide.	Mangan. peroxide.	Volatile.	Total.	
1	66·40	25·30	8·85	...	1·45	...	0·45	102·45	Arfvedson, Utoe.
2	63·29	28·78	5·63	...	0·79	0.20	0·78	99·47	Stromeyer, do.
3	65·30	25·34	6·76	...	2·83	..	...	100.23	Reynault, do.
4	66·14	27·02	3.81	2·68	0·32	...	...	100	Hagen, do.
5	65·25	27·55	...	...	...	...	...	...	Do. Mexico.
6	66·03	26·45	...	...	...	...	...	...	Do. Tyrol.

The soda was first noticed by Hagen, being formerly included in the lithia. Spodumene was found with felspar, quartz, and tourmaline, in a bed of magnetic iron ore in gneiss at Utoe, Sweden, more recently also at Sterzing and Lisens in the Tyrol; Killiney near Dublin; Peterhead in Scotland; and at Sterling Massachusetts, and other places in America.

Killinite, a greenish-grey or yellowish mineral, perhaps only a decomposed spodumene, is found with it at Killiney. H. = 4; G. = 2·65.

Breathed on, emits a bitter odour. B.B. melts to a white enamel. Analyses.

	Silica.	Alumina.	Pot ash.	Magnesia.	Lime.	Iron protox.	Mang. perox.	Water.	Total.	
1	49·08	30·60	6·72	1·08	0·68	2·27	trace.	10·00	100·43	Lehunt.
2	47·93	31·04	6·06	0·46	0·72	2·33	1·25	10·00	99 80	Blythe.

14. KASTOR, *Breithaupt.*

Monoclinohedric of unknown dimensions. Cleavage distinct in two directions (vertical and clinodiagonal), meeting at 128½°. Fracture conchoidal. H. = 6, — 6·5; G. = 2·38 — 2·40. Transparent; splendent vitreous lustre. Colourless. B.B. melts with difficulty in thin splinters to a transparent colourless bead, tinging the flame deep carmine-red. With borax and soda forms a clear glass. Chem. com. $2\,\ddot{Al}^2\,\ddot{Si}^9 + \dot{Li}^2\,\ddot{Si}^9$ = 78·0 silica, 19·3 alumina, and 2·7 lithia. Mean of three analyses.

	Silica.	Alumina.	Iron perox.*a*	Lithia.*b*	Total.	
1	78·012	18·856	0·613	2·760	100·261	Plattner.

(*a*) With traces of manganese; (*b*) with traces of soda and potash.

Found with pollux in the druses of granite in Elba. It much resembles quartz in aspect, and is the most siliceous of the crystalline silicates.

15. POLLUX, *Breithaupt.*

Crystallization unknown. Traces of cleavage. Fracture conchoidal. H. = 6 — 6·5; G. = 2·87 — 2·89. Transparent; splendent vitreous lustre; colourless. Is optically binaxial. B.B. alone, loses its transparency, and melts on thin edges to an enamel-like porous glass, colouring the flame reddish-yellow. With soda melts with effervescence to a clear bead, and with more of the flux at last sinks into the charcoal. In the closed tube yields water, and becomes opalescent. Analysis.

	Silica.	Alumina.	Iron perox.	Potash.	Soda.	Water.	Total.	
1	46·20	16·39	0·86	16·51	10·47	2·32	92·75	Plattner.

The soda contained traces of lithia, and the great loss arose from the small quantity operated on. It is thus scarcely possible to give any formula for this mineral, and its place in the system is also un-

certain. It was found along with kastor, and like it much resembles quartz.

16. AMORPHOUS FELSPAR. Fusible quartz, *Jameson;* Pyraphrolite, *Hausmann;* Empyrodox quartz, *Mohs.*

Under these names several mineral substances, with no regular structure, but a more or less vitreous aspect, are included. Fuchs considers them as mixtures of felspar and opal. They are rather rocks than minerals, and have arisen in the rapid cooling of fused masses, preventing the separation and regular crystallization of their various constituents.

(*a.*) OBSIDIAN. Compact in globular grains or masses. Fracture perfect conchoidal; brittle. H. = 6—7; G. = 2·2—2·4. Semi-transparent to translucent on the edges. Lustre vitreous or resinous. Usually coloured black, grey, green, red, and brown, or striped and spotted. B.B. melts quietly or with effervescence to a foamy mass, a glass or enamel. Chem. com. very indeterminate. Analyses.

	Silica.	Alumina.	Soda.	Potash.	Lime.	Magnesia.	Iron perox.		Total.	
1	78	10	...	6	1	...	2	1·6*a*	98·6	Vaquelin.
2	72·0	12·5	...	10.0	...	...	2·0	...	96·5	Collet-Descotils.
3	81·00	9·50	7·20		0·33	...	0·60	0·50*b*	99·13	Klaproth.
4	77·50	11·75	7·00		0·50	...	1·25	0·50*b*	98·50	Do.
5	74·80	12·40	...	6·40	1·96	0·90	2·03	1·31*c*	99·80	Erdmann.
6	69·46	2·60	5·08	7·12	7·54	2·60	2·60	3·00*d*	100	Berthier.
7	84·00	4·64	3·55	...	2·39	...	5·01*e*	...	99·59	Thomson.
8	70·34	8·63	3·34	...	4·56	1·67	10·52*e*	0·32*c*	99·38	Damour.
9	75·20	6·66	7·57		3·83*f*	...	6·54	...	100	Murdoch.
10	70·97	6·77	11·41		2·84	1·77	6·24	...	100	Do.

(*a*) Manganese; (*b*) water; (*c*) manganese protoxide; (*d*) volatile matter; (*e*) protoxide; (*f*) with magnesia.

From (1) Cerro de las Navajas near Mexico; (2) Mexico; (3) light-coloured Ochotzk; (4) dark do.; (5) Telkebanya; (6) Pasco; (7) Iceland; (8) India; (9) Bay of Islands, New Zealand, G. = 2·386; (10) Ascension Island.

The nature of the alkali in some of the above analyses seems not well ascertained. In obsidian from Procida, Abich found 6·09 per cent. soda, and 4·35 potash; in that of Teneriffa 10·63 soda, and 3·50 potash.

Occurs in streams or detached masses near many volcanoes, as in Iceland, the Lipari islands, Milo, Santorin, Teneriffa, Mexico, and Hungary. The ancient Mexicans formed it into mirrors, knives, razors, arrow-heads, and similar arrow-heads are found in the Greek tumulus at Marathon. It is sometimes porphyritic from enclosed crystals of glassy felspar. Damour gave a piece of Indian Obsidian

(No. 8 analysis) to a lapidary to divide: when sawn all round for about two-thirds of its thickness, a hissing sound was heard, and the free part broke to pieces with a violent detonation.

(*b.*) PUMICE. Bimstein, *Werner;* Ponce, *Beudant.* Porous, vesicular, or fibrous. Fracture conchoidal or flat; very brittle. Colours white, grey, passing into yellow, brown, or black. H. = 5; G. in powder 2·19 — 2·2; in masses swims on water. B.B. melts more or less easily to a white enamel. Chem. com. indeterminate.

	Silica.	Alumin.	Potash.	Soda.	Lime.	Iron perox	Watr.	Total.	
1	77·50	17·50	3·00		...	1·75	...	99·75	Klaproth; Lipari.
2	70·00	16·00	6·50	...	2·50	0·50	3·00	98·50	Berthier; Lipari.
3	69·25	12·75	0·87	0·87	3·50	4·50	7·00	99·12	Brandes.

Abich found 6·21 per cent. soda and 3·98 potash in pumice from Ischia.

Pumice occurs in most volcanic countries, and especially with obsidian, in the localities above-mentioned. At Andernach on the Rhine, it is used as a building stone; and it is largely exported from Lipari, where it forms a hill 800 to 1000 feet high, and from the Ponza islands. Pumice is rather a peculiar state of the obsidian or trachytic lavas than any distinct mineral compound.

(*c.*) PEARLSTONE. Perlstein, *Werner;* Perlaire, *Hauy.* Roundish concentric globules imbedded in a vesicular basis. Fracture conchoidal; very brittle. H. = 6; G. = 2·2 — 2·4. Pearly lustre. Colour reddish, bluish, or ash-grey; also yellow, red, or brown in stripes or spots. B.B. melts to a white fungus-like mass. Chem. com. indefinite. Analyses.

	Silica.	Alumina.	Potash.	Soda.	Lime.	Magnesia.	Iron perox.	Water.	Total.	
1	72·25	12·00	4·50	...	0·50	...	1·60	4·50	98·35	Klaproth.
2	79·12	12·00	3·58		...	1·10	2·45	1·76	100·01	Ficinus.
3	72·87	12·05	6·13		1·30	1·10	1·75	3·00	98·20	Erdmann.
4	77·20	12·47	4·2		3·34	0·73	2·27	...	100·28	Do.
5	69·53	11·00	3·40		8·33	1·30	4·00	0·30*a*	99·166	Do.
6	74·83	13·49	trace.	5·56	1·98	0·17	4·40	...	100·43	Forchhammer.

(*a*) + 2·30 manganese protoxide.

From (1) Tokay; (2, 3) Hlinick in Hungary; (4) Sphaerulite from Hlinik; (5) Do. Spechthausen; (6) Krablite from Hrafntinnabruggr, Iceland, G.= 2·389.

Occurs in Hungary, Siberia, Mexico, forming whole hills or extensive beds of rock. The sphærulite forms small spherical concretions in pearlstone in Hungary and Mexico; in pitchstone at Spechthausen, Saxony, and in obsidian on Santorin. It is also found with pitchstone in Arran, and in clay in Shetland.

(*d*) PITCHSTONE. Pechstein, *Werner;* Feldspath résinite, *Hauy;* Retinite, *Beudant.* Compact, slaty or in concentric scaly concretions. Fracture conchoidal, splintery, H. = 5·5 — 6; G. = 2·2—2·3 (H. 6·5, G. 2·34 — 2·36, *Thomson.*) Subtranslucent to opaque. Lustre vitreous or resinous. Grey, green, yellow, red, brown, black. B.B. melts to a porous glass or grey enamel. Chem. com. indefinite. Analyses.

	Silica.	Alumina.	Lime.	Soda.	Potash.	Iron perox.	Magnesia.	Water.	Total.	
1	73·00	14·50	1·00	1·75	..	1·00	0·10 *a*	8·50	99·85	Klaproth.
2	75·60	11·60	1·35	2·77	...	1·29	6·69	4·73	103·94	Erdmann.
3	72·80	11·50	1·12	2·88	...	3·03	...	8·50	99·82	Knox.
4	63·50	12·74	4·46	6·22	...	3 80	...	8·00	98·72	Thomson.
5	67·6	8·7	3·5	5·7	5·5	3·6	1·6	...	96·2	Berthier.

(*a*) Manganese peroxide; (*b*) + protoxide with bitumen and volatile matter.

Forms beds or veins at Tokai, Kremnitz, Schemnitz in Hungary; Meissen, Saxony, (anal. 1); near Newry, Ireland, (No. 2); and Arran, Scotland, (Nos. 3 and 4). That from the latter island is said to contain two per cent. of bitumen. The volatile matter in Thomson's analysis was not examined, but considered by him as water. No. 4 is named Petrosilex by Berthier; but its deep blackish-green colour and vitreous lustre show it to have been pitchstone. The great loss is probably from volatile matter. Berthier compares it to the obsidian of Pasco (No. 6 above). In one place near Clachland Point, it occurs in ellipsoidal masses compressed on the sides, and with a concentric structure, resembling miniature joints of basaltic columns. In a black variety from near Dresden, Tromsdorf said he found 3·0 per cent. lithia; but this has not been confirmed.

III. FAMILY.—SCAPOLITE.

17. SCAPOLITE, *D'Andrada, Werner, Phillips, &c.;* Wernerite, Meionite, *Hauy, Phillips &c.;* Pyramidal Elain-spar, *Mohs.*

Tetragonal; P. 63° 48′, *Mohs;* usual combinations, ∞P∞ (*M.*) P(*r*) . ∞P(*z*), or ∞P . ∞P∞ . P. Rarely faces of other forms are seen; among them a ditetragonal pyramid, hemihedrally developed. The crystals are often long prismatic, and occur imbedded or in drusy cavities. Also found massive with granular or columnar structure. Cleavage, prismatic along ∞P∞, rather perfect; along ∞P less perfect. H. = 5 — 5·5; G. = 2·6 — 2·8. Transparent or translucent. Lustre vitreous, occasionally pearly or resinous. Co-

lourless, but coloured pale grey, green, yellow, or red. B.B. melts with effervescence to a vesicular glass. In the closed tube, many show traces of fluorine. With solution of cobalt become blue. Soluble in hydrochloric acid, some (meionite of Vesuvius) gelatinizing. Analyses.

	Silica.	Alumina.	Lime.	Soda.	Potash.	Magnesia.	Iron protx.	Watr.	Total.	
1	43·83	35·28	19·37	...	...	...	0·61	...	99·04	Walmstedt.
2	43·83	35·43	18·96	...	...	...	...	1·03	99·25	Nordenskiöld.
3	43·80	32·85	20·64	2·57*a*	...	...	1·07	...	100·93	L. Gmelin.
4	40·53	32·73	24·25	1·81		...	0·18	...	99·50	Stromeyer.
5	45·35	31·67	23·95	...	...	...	...	...	100·97	Thomson.
6	49·42	25·41	15·59	6·05	...	0·68	perox 1·40	1·45	100	Hartwall.
7	48·77	31·05	15·94	3·25	...	...	..	0·61	99·62	Do. and Hedberg.
8	52·11	27·60	13·53	3·86	...	0·55		0·73	98·38	Do. Do.
9	51·34	32·27	9·33	5·12	...	1·91		1·00	100·97	Do. Do.
10	41·25	33·58	20·36	...	...	0·54*b*	...	3·32	99·05	Nordenskiöld.
11	46·30	26·48	18·62	3·64*a*	...	...	...	5·04	100·08	Thomson.
12	49·88	27·02	12·71	7·59	0·87	0·85	0·21	0·77	99·90	Wolff.
13	48·15	25·38	16·63	4·91	0·12	0·84	1·48	0·85	98·45	Do.
14	48·79	28·16	15·02	4·52	0·54	1·29	0·32	0·74	99·36	Do.
15	49·26	26·40	14·44	6·14	0·65	...	0·54	0·69	98·12	Do.
16	50·91	25·81	13·34	7·09	0·85	0·58	0·76	0·41	99·74	Do.
17	45·10	32·76	17·84	0·76	0·68	...	...	1·04	98·18	Do.
18	42·07	31·71	22·43	0·45	0·31	...	...	0·31	97·29	Do.
19	61·50	25·75	3 00	...	...	0·75	1·50*c*	5·00*c*	99·00	Berzelius.
20	46·35	26·34	17·00	4·71	0·32	0·54	0·32	1·60*d*	98·17	L. M. Berg.

(*a*) With lithia; (*b*) with manganese protoxide; (*c*) + 1·5 manganese perox.; (*d*) + 0·99 undecomposed matter; (*e*) including also soda and potash.

From (1) Tunaberg; (2) Ersby, near Pargas, Finland, (Wernerite); (3, 4) Monte Somma, Meionite); (5) North America; (6) Pargas (Ekebergite); (7, 8) Ersby (Wernerite); (9) Petteby (do.); (10) Ersby (scapolite); (11) Bolton, Massachusets; (12—19) mostly means of several trials; water = loss by heat; (12) Malsjo, Wermeland, reddish or greenish-white, massive, G. = 2·623; (13) Hirvesalo, Finland, blackish or greenish, crystals or compact. Ekebergite, G. = 2·733; (14) Bolton, Massachusets, reddish and whitish crystalline, Ek. G. = 2·718; (15) Hesselkulla, massive, greyish-green, Ek. G. = 2·735; (16) Arendal, white or yellow, thin crystals of Ek. in limestone, G. = 2·712; (17) Pargas, colourless crystals of sc. G.= 2·712; (18) Vesuvius, meionite; (19) Sjösa, Sweden, red opaque crystals, G.= 2·643, probably metamorphosed; (20) Bocksäters, East-Gothland, massive sc. violet, G. = 2·34.

Nos. 12–17 were easily fusible. B.B. forming a white porous glass, and colouring the flame yellow. With salt of phosphorus they showed traces of fluorine, but not in the moist way. No. 19 was only fusible with much difficulty on the edges.

Notwithstanding these numerous analyses, the constitution of this mineral is still uncertain, as they lead to no general formula. Rammelsberg divides them into three classes. First, scapolite, = $(\dot{C}a^3, \dot{N}a^3)\ddot{S}i^2 + 2\ddot{A}i\,\ddot{S}i$ (or $3\dot{R}\,\ddot{S}i + \ddot{A}i^2\,\ddot{S}i^3$) with 50 per cent. silica, and 4 — 7½ soda, including Nos. 6, 8, 12–16, above. Second, Meionite $\dot{C}a^3\,\ddot{S}i^2 + 2\ddot{A}i\,\ddot{S}i$, with about 42 per cent. silica and 1 — 3 soda and potash. Naumann proposes for this variety $\dot{C}a^3\ddot{S}i^2 + 2\ddot{A}i\,\ddot{S}i$ with 40 sil., 33 al., and 27 lime, includes Nos. 3, 4, 18. This is the formula

of the lime-epidote or zoisite, and the substance is consequently dimorphous. Third, Wernerite = $\dot{C}a^3$ ''' + $3\ddot{A}i$ $\ddot{S}i$ (or $\dot{C}a$ $\ddot{S}i$ + $\ddot{A}l$ $\ddot{S}i$) with 44–45 per cent. silica, and 0 — 1½ alkali. To this belongs Nos. 1, 2, 17. This formula is also that of anorthite, and the substance is again dimorphous. In these compounds the oxygen of $\dot{R}$ $\ddot{A}i$, and $\ddot{S}i$ have the proportions, 1 : 2 : 4, 1 : 2 : 3, and 1 : 3 : 4 respectively. The agreement of these compounds in crystalline form deserves further investigation, and also the proportion of fluorine they contain. Nos. 10, 11 are remarkable for the amount of water.

The above are the principal localities of this remarkable mineral. It occurs chiefly in veins of magnetic iron, copper pyrites, or other ores, and in beds of granular limestone, and is most commonly associated with calc-spar, quartz, felspar, mica, augite, hornblende, and garnet. The fine transparent glassy variety, or meionite, is found in the ejected blocks on Vesuvius.

The following five minerals are closely related to scapolite, if not mere impure or compact varieties.

18. NUTTALITE, *Brooke.*

Tetragonal, P 64° 40′; forms and cleavage like scapolite. H. = 5·5, G. = 2·74 — 2·75. Vitreous, on fracture resinous. Colour ash or greenish-grey. B.B. like scapolite. Chem. com. $2\ddot{A}i$ $\ddot{S}i$ + $3\dot{R}^2$ $\ddot{S}i$. Analysis of specimen from Bolton, Massachusets.

Sil.	Al.	Lime.	Soda.	Potass.	Iron protox.	Water.	Total	
37·81	25·10	18·34	...	7·31	7·89	1·50	97·95	Thomson.

19. BARSOWITE, *G. Rose.*

In fine granular or compact masses, with a distinct cleavage, at least in one direction, H. = 5·5 — 6; G. = 2·74 — 2·76. Translucent on the edges; lustre, pearly; colour, snow-white; B.B. melts with difficulty on the edges to a vesicular glass; with salt of phosphorus leaves a siliceous skeleton, with cobalt solution becomes blue. Gelatinizes in warm hydrochloric acid. Chem. com. $\ddot{A}i^2$ $\ddot{S}i^3$ + $2(\dot{C}a, \dot{M}g,)$ $\ddot{S}i$. Analyses.

	Silica.	Alumina.	Lime.	Magnesia.	Total.	
1	49·01	33·85	5·46	1·55	99·87	Varentrapp.
2	49·05	33 78	5·30	1·42	98·56	Do.
3	48·07	34·08	5·10	1·65	98·90	Do.

It occurs in the auriferous sands of Barsowskoi in the Ural, and often includes crystals of corundum, pleonaste, and mica.

The *Bytownite* of Thomson, from Bytown in Upper Canada, seems connected. It is crystalline with traces of cleavage, and a splintery fracture; H. = 6; G. = 2·8. Translucent; lustre vitreous; colour light greenish-blue. B.B. infusible but becomes white. Chem. com. $(\ddot{A}l, \ddot{F}e)\ \ddot{S}i + (\dot{C}a, \dot{N}a^2, \dot{M}g)^2\ \ddot{S}i^3$, nearly corresponding with the mean of two analyses by Thomson, = 47·57 silica, 29·65 alumina, 3·57 iron peroxide, 9·06 lime, 7·60 soda, and 0·20 magnesia.

20. Ottrelite, *Hauy.*

Occurs in thin hexagonal tables, about a line broad, with a rather perfect cleavage parallel to the lateral faces. Scratches glass; G.=4·4. Translucent; vitreous; and greenish or blackish-grey. B.B. melts difficultly on the edges to a black magnetic globule. With borax, slowly fusible with reaction for iron; with soda, strong reaction for manganese. Powder soluble only in warm sulphuric acid. Chem. com. $\ddot{A}l^2\ \ddot{S}i^3 + 3(\dot{F}e, \dot{M}n)\ \ddot{S}i + 3\dot{H}$. Analyses.

	Silica.	Alumina.	Iron protox.	Mangan. protox.	Water.	Total.	
1	43·52	23·89	16·81	8·03	5·63	97·88	Damour.
2	43·34	24·63	16·72	8·18	5·66	98·53	Do.

Found in grey clayslate at Ottrez, near Stavelot, on the border of Luxemburg.

21. Palagonite, *S. v. Waltershausen.*

Amorphous, fracture couchoidal, or uneven. Easily frangible. H. nearly 5 (Bunsen), rather more than calc-spar (S. v. W.); G.=2·4296. Transparent or translucent; lustre resinous, inclining to vitreous; colour wine-yellow to yellowish-brown; sometimes coffee-brown in reflected, honey-yellow in transmitted light. When heated evolves water, and becomes dark-brown. B.B. fuses readily to a shining magnetic bead. Easily soluble in hydrochloric acid, with separation of silica. Chem. com. $(\ddot{A}l^2, \ddot{F}e^2)\ \ddot{S}i^3 + 3\ (\dot{C}a, \dot{M}g, \dot{N}a)\ \ddot{S}i + 9\dot{H}$. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Magnesia.	Soda.	Potash.	Water.	Insoluble remains.	Total.	
1	37·42	11·16	14·17	8·77	6·04	0·65	0·68	17 15	4·11	100·15	Bunsen.
2	32·91	8·93	12·87	7·55	4·24	1·28	0·99	14·64*a*	9·57	100·08	Do.

(*a*) + 7·10 hygroscopic water.
No. 1, from Seljadalr; No. 2, from tufa Hekla.

This mineral was discovered by Sartorius v. Waltershausen in the tufa of Palagonia, in the Val di Noto, Sicily; and more recently in that of Iceland, where it is very abundant. In composition it resembles ottrelite with thrice the water, or is a hydrous scapolite.

22. DIPYR, *Hauy;* Schmelzstein, *Werner.*

Tetragonal, in apparently regular, but rounded eight-sided prisms. Cleavage like scapolite. Scratches glass, G. = 2:646. Vitreous; colour, whitish or reddish B.B. becomes opaque, and melts readily to a white vesicular glass. Slightly affected by acids. Chem. com. $3\ddot{A}i\ \dot{S}i + 4\ (\dot{C}a,\ \dot{N})\ \dot{S}i^2 = 55{\cdot}7$ silica, 25·1 alumina, 9·1 lime, and 10·1 soda. Analysis from the mean of four.

	Silica.	Alumina.	Lime.	Soda.	Potash.	Total.	
1	55·5	24·8	9·6	9·4	0·7	100	Delesse.

The dipyr occurs imbedded in slate or limestone at Mauléon, and in the valley of Castillon, in the Pyrenees. Its form has caused it to be joined to scapolite; but Rammelsberg remarks the analysis brings it nearer to labradorite.

23. NEPHELINE, *Hauy, Werner, Phillips;* Elæolite, *Karsten;* Rhombohedral Elæin-spar, *Mohs.*

Hexagonal; P 88° 6′, usual combinations, ∞P . 0P and ∞P . 0P . P. Crystals small, imbedded, or in druses; also massive and large granular; cleavage basal, and prismatic along ∞P, imperfect. Fracture conchoidal or uneven; H. = 5·5 — 6; G. = 2·58 — 2·64. Transparent or translucent, lustre vitreous, colourless, or white (Nepheline); or more opaque, dull resinous lustre, and green, red, or brown colours, (Elæolite.) B.B. melts difficultly (nepheline), or easily with slight effervescence (elæolite) into a vesicular glass. Soluble in borax, and with difficulty in salt of phosphorus. Becomes blue with solution of cobalt. Wholly dissolved and gelatinizes in hydrochloric acid. Chem. com. $\ddot{A}i^5\ \dot{S}i^6 + 4\ \dot{N}a\ \dot{S}i + \dot{K}\ \dot{S}i$. Analyses.

	Silica.	Alumina	Soda	Potash.	Lime	Magnesia.	Iron perox	Watr.	Total.	
1	44·11	33·73	20·46	...	...	...	...	0·62	98·92	Arfvedson, Somma.
2	44·12	33·46	15·43	4·73	1·87	trace	0·49	0.21	100·31	Scheerer, Do. M. of 3.
3	43·70	32·31	15·83	5·60	0·84	...	1·07	1·39	100·74	Scheerer, Odenwald.
4	43·36	33·49	13·36	7·13	0·90	...	1·50	1·39	101·13	L. Gmelin, do.
5	45·23	32·66	15·72	5·66	0·33	...	0·56	0·62	100·78	Scheerer, Fredriksvarn.
6	45·55	32·09	16·09	5·02	trace	...	1·41	0·78	100·85	Do. do.
7	44·53	32·08	15·72	5·17	0·26	...	1·08	2·06	100·90	Do. Brevig.
8	44·07	33·12	15.70	5·69	0·26	trace	0·57	0 90	100·31	Scheerer, Miask.
9	41·42	34·06	15·13	6·43	0·34	0·61	trace	0·46	99·41	Bromeis, Do.

Nos. 1–4 are the nepheline or more transparent crystalline varieties. No. 1, remarkable as showing no potash, and No. 2 a mean of three trials, are from ejected blocks on Monte Somma, where it is associated with meionite, &c. It also occurs in the leucite-lava at Capo di Bove and other places near Rome; and in the dolerite of the Katzenbuckel in the Odenwald (Nos. 3, 4), at Aussig Bohemia, and in the Lausitz. The elæolite (Nos. 5–9) occurs in the zircon syenite of Southern Norway at Laurvig, Fredriksvärn (No. 5, green, mean of 2; No. 6, brown var.), and Brevig, (No. 7, brown, mean of 2) It is a constituent of the miascite of the Ilmen Mountains near Miask (No. 8, mean of 2, and No. 9, both white). In this variety Bromeis found 0·04 per cent. hydrochloric acid, and Scheerer 0·06 per cent. of this, with 0·07 per cent. sulphuric acid. The latter found 0·22, and in a purer variety 0·05 hydrochloric acid, with traces of sulphuric acid in nepheline from Vesuvius.

The *Cavolinite* and the *Beudantite* of Monticelli and Covelli seem only nepheline. Beudant considers the Indianite as a lime-nepheline, but it seems nearer anorthite.

24. DAVYNE, *Monticelli and Covelli;* Cancrinite, *G. Rose;* Peritomous Elæin-spar, *Mohs.*

Hexagonal; P 51° 46′, usual combinations ∞P . 0P, and ∞P. ∞P2 . 0P . P. Also massive and columnar. Cleavage prismatic along ∞P, very perfect. H. = 5 — 5·5; G. = 2·42 — 2.46. Translucent, or in thin fragments transparent. Lustre resinous, on cleavage planes vitreous or pearly. Colourless, white, or greyish, also rose red (cancrinite). B.B. melts to a white vesicular glass. Soluble with effervescence in hydrochloric acid, leaving gelatinous silica. Chem. com. $\ddot{A}i^5 \dot{S}i^6 + 5\ \dot{N}a\ \dot{S}i + 2\ \dot{C}a\ \ddot{C}$ (or one atom of a nepheline silicate with two atoms carbonate of lime), = 40 silica, 30 alumina, 18 soda, and 12 carbonate of lime. Analyses.

	Silica.	Alumina.	Iron & mang. perox.	Soda.	Potash.	Lime.	Carbonic acid.	Water.	Total.	
1	42·91	33·28	3·11 *a*	...	...	12·02	...	7·43	100	Mont. and Cov.
2	40·59	28·29	...	17·38	0·57	7·06	6·38	...	100·27	G. Rose.
3	40·26	28·24	...	17·66	0·82	6·34	6·38	...	99·70	Do.
4	37·42	27·70	0.86	20·98	0·67	3·91	5·95	2·82 *b*	100·31	Whitney.
5	37·89	27·39	0·64	21·24		3·88	5·95	2·82 *b*	99·81	Do.
6	37·20	27·59	0·27	20·46	0·50	5·26	5·92	3·28 *b*	100·48	Do.
7	40·58	28·57	0·89 *c*	3·50	...	20·20	6·40	...	100·14	Hermann.

(*a*) Iron perox. +1·25 manganese perox.; (*b*) + traces of chlorine; (*c*) protoxide.

The davyne (No. 1) was discovered in the ejected blocks on Mount Vesuvius, and the above analysis furnished by Monticelli and

Covelli. Mitscherlich next showed that it contained all the elements of nepheline, and, besides, chlorine and lime; and then Breithaupt identified it with the cancrinite. This is found in the miascite of the Ilmen mountains (Nos. 2, 3). Also lately at Litchfield in Maine (Nos. 4, 5, yellow, crystalline, and granular, G. = 2·448 No. 6, greenish variety, G. = 2·461); but the carbonate is here $\dot{N}a\,\ddot{C} + \dot{C}a\,\ddot{C} + 2\frac{1}{2}\,\dot{H}$, or gaylussite with half the amount of water. No. 7 is the *Stroganowite*, found in loose blocks in the Slüdänka, a river of Dauria. It agrees with davyne, except in the soda being chiefly replaced by lime; and Hermann asserts that it is cleavable only in two directions almost at right angles.

25. GEHLENITE, *Fuchs, Werner, Hauy, Phillips;* Pyramidal Adiaphane Spar, *Mohs.*

Tetragonal; P 65° 50′ (Brooke). Generally only the simple combination 0P . ∞P seen; the crystals, thick tabular or short prismatic, are imbedded or form loose aggregates. Cleavage, basal rather perfect, prismatic along ∞P traces. H. = 5·5 — 6; G. = 2·98 — 3·1. Translucent on the edges to opaque. Lustre dull resinous. Mountain, leek, or olive-green, to liver-brown. B.B. melts difficultly in thin fragments (= 5·7, v. Kobell). Gelatinizes with hydrochloric acid. Chem. com. $\dot{R}^3\,\ddot{S}i + \ddot{R}\,\ddot{S}i$, with 31·4 silica. Analyses.

	Silica.	Alumina.	Lime.	Magnesia.	Iron protox.	Iron perox.	Soda.	Water.	Total.	
1	29·64	24·80	35·30	...	6·56 *a*	...	...	3·30	99·60	Fuchs.
2	31·0	21·4	37·4	3·4	4·4	...	...	2·0	99·6	v. Kobell.
3	29·13	25·05	37·38	...	4·35	...	...	4·54	100·45	Thomson.
4	31·60	19·80	38·11	2·20	...	5·97	0·33	1·53	99·54	Damour.
5	30·47	17·79	36·97	2·99	...	7·30	...	3·62	99·14	Kuhn.
6	29·52	19·00	36·55	1·41	7·25	...	...	5 55	99·28	Do.
7	29·78	22·02	37·90	3·88	1·73	3·22	0·19*b*	1·28	100	Rammelsberg.
8	39·80	12·80	37·64	4·64	...	2·57	0·30*c*	2·0	99·75	v. Kobell.

(*a*) Proto-peroxide of iron; (*b*) manganese protoxide; (*c*) potash.

The state of oxidation of the iron was first determined by Rammelsberg (No. 7). In the former analyses it was merely assumed. In a second trial he found 2·92 perox.

Found only in Mount Monzoni in the Fassa valley with calc-spar. No. 8 is a compact mineral with similar physical characters from the same place, but appears more to resemble Humboldtilite.

26. HUMBOLDTILITE, *Monticelli and Covelli* (including Melilite, Somervillite, Zurlite), *Hauy, Phillips, Mohs, &c.*

Tetragonal; P 65° 30′; the most common combination is 0P . ∞P, thick tabular or short prismatic. Cleavage, basal perfect. H. = 5 — 5·5; G. = 2·90 — 2·95. Translucent on the edges, or rarely semi-

transparent. Lustre vitreous, or on fracture resinous; colour yellowish-white, honey-yellow, and yellowish-brown. B.B. melts easily to a light or blackish coloured glass. Gelatinizes with hydrochloric acid. Chem. com. generally $2\,\dot{R}^2\,\ddot{S}i^3 + \dddot{R}\,\ddot{S}i$, where $\dot{R}$ is chiefly lime and magnesia, with some soda and potash; $\dddot{R}$ alumina and iron-peroxide. Analyses.

	Silica.	Alumina.	Lime.	Magnesia.	Iron perox.	Soda.	Potash.	Total.	
1	43·96	11·20	31·96	6·10	2.32*a*	4·28	0·38	100·20	v. Kobell.
2	40·69	10·88	31·81	5·75	4·43	4·43	0·36	98·35	Damour.
3	39·27	6·42	32·47	6·44	10·17	1·95	1·46	98·18	Do.
4	38·34	8·61	32·05	6·71	10·02	2·12	1·51	99·36	Do.
5	42·11	24·50	32·43	...	...	2·93	...	101·97	Scacchi.

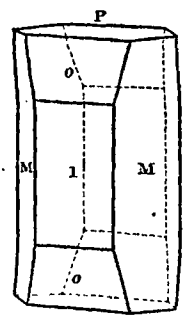
(*a*) Protoxide.

Occurs in the ejected blocks on Vesuvius (Nos. 1, 2) with calc-spar, mica, and augite. The melilite (3 a pale yellow, 4 a brown variety) is found at Capo di Bove near Rome, in lava with nepheline, either imbedded or in druses. Carpi found titanic acid (4·0 per cent.) in his analysis. The *sarkolite* of Thomson is, by Breithaupt and others, united with Humboldtilite; whilst Descloizeaux thinks the crystallographic characters as given by Brooke distinguish it. It is tetragonal; P 102° 54′; is white or flesh red; vitreous lustre; and translucent. It is also from ejected Vesuvian blocks. Analysis No. 5.

27. PREHNITE, *Werner, Hauy, Phillips, &c.*; Koupholite, *Lametherie*; Axotomous Triphane-spar, *Mohs.*

Rhombic, ∞P 99° 56′, $3\breve{P}\infty$ 33° 0′, $\frac{3}{8}\overline{P}\infty$ (*n*) 126° 40′; most common combinations, 0P . ∞P, or also with $\infty\breve{P}\infty$; and ∞P (*m*) . 0P (*P*) . $\infty\breve{P}\infty$ (*l*) . $3\breve{P}\infty$ (*o*), fig. 112. The crystals are tabular or short prismatic, combined in druses, in fan-shaped or cock's-comb groups. Also found granular, and in spherical, reniform masses, with a laminar or fibrous structure. Cleavage basal, rather perfect, prismatic along ∞P imperfect. H. = 6—7; G. = 2·8 — 3. Semitransparent or translucent on the edges. Lustre, vitreous, on 0P pearly. Colourless, but mostly coloured greenish-white, olive, apple, or leek-green. Streak, white. When heated becomes polar-electric. In the closed tube yields water without losing its transparency. B.B. melts easily, and with much intumescence to a porous enamel. Soluble in concentrated hydrochloric acid, but only gelatinizes perfectly when

Fig. 112.



previously ignited or fused. Chem. com. $2\dot{C}a\,\ddot{S}i + \dot{A}l\ddot{S}i + \dot{H} = 44{\cdot}4$ silica, 24·6 alumina, 26·7 lime, and 4·3 water. Analyses.

	Silica.	Alumina.	Lime.	Iron perox	Mang. perox.	Watr.	Total.	
1	43·00	23·25	26·00	2·00	0·25	4·00*a*	98·50	Gehlen, Ratschinges.
2	42·88	21·50	26 50	3·00	0·25	4·63	98·76	Do. Fassa.
3	43·03	19·30	26·28	6·81	0·15	4·43	100·20	Walmstedt, Aedelforss.
4	44·71	23·99	25·41	1·25*b*	0·19	4·45	100	Do. Mont Blanc.
5	44·10	24·26	26·43	0·74*b*	...	4·18	99·71	Do. Dumbarton.
6	43·60	23·00	22·33	2·00	...	6·40	97·33	Thomson, Glasgow.
7	44·74	18·06	27·06	7·38	1·03*c*	4·13	102·40	Amelung, Radauthal.
8	42·50	30·50	22·57	0·04	0·02*d*	5·00	100·63	G. Leonhard, Niederkirchen.
9	44·00	28·50	22·29	0·04	0·01*d*	6·00	100 84	Do. do.

(*a*) Traces of soda and potash; (*b*) iron-protoxide; (*c*) soda; (*d*) potash.

Occurs in various rocks, as granite, euphotide, and greenstone, sometimes disseminated, but more commonly in fissures, veins, and druses. It was first found at the Cape of Good Hope in 1779. Very fine crystals occur at Bourg d'Oisans in Dauphiné, and Ratschinges, near Sterzing in Tyrol. Common in the Alps, Pyrenees, Harz (No. 7 in Euphotide), and Norway. In Scotland it is found in trap at Friskie Hall, and Campsie, Dumbartonshire (white and opaque); Hartfield Moss, Renfrewshire; Corstorphine Hill, the Castle Rock (translucent and colourless), and Salisbury Craigs (yellow), near Edinburgh. No. 3 is the so-called ædelite, and No. 4 the koupholite. No. 8 is a pseudomorph in the form of analcim, and No. 9 in that of leonhardite. According to Reiss and Rose, the pyro-electricity has central polarity; the analogue pole being in the middle of the shorter diagonal of the basis, and two antilogue poles at its extremities, and consequently the acute edges of the prism are non-electric.

28. The following minerals, whose true place in the system is still uncertain, may follow prehnite.

(*a.*) *Zeuxite* of Thomson: found in Huel Unity Mine, near Redruth, Cornwall, in acicular crystals, apparently rectangular prisms, collected in fibrous masses, H. = 4 — 5; G. = 3·0 — 3·1; Opaque; lustre, vitreous; greenish brown. B.B. infusible alone; with borax forms a dark-brown glass. Analysis No. 1, which gives nearly $3\dot{A}l\,\ddot{S}i + 2\dot{R}^2\ddot{S}i + 3\dot{H}$, when $\dot{R} = \frac{5}{9}Fe + \frac{4}{9}\dot{C}a$.

(*b.*) *Kirwanite* of Thomson: found in basalt in the Mourne Mountains, Ireland, in spheroidal masses, with a radiating fibrous texture, H. = 2; G. = 2·9. Opaque; dark olive-green. B.B. becomes black, and partially fuses. With soda or borax forms a dark-brown glass. Chem. com. $3\dot{C}a\,\ddot{S}i + 3\dot{F}e\,\ddot{S}i + \dot{H}^2\dot{A}l$. Analysis No. 2.

(*c.*) *Huronite* of Thomson: in rounded granular or foliated masses, in loose blocks on Lake Huron, North America, H.=3·25; G.=2·86.

Translucent; pearly or resinous lustre; colour pale yellowish-green; streak greyish-white. B.B. infusible, but becomes greyish-white; with borax forms a greenish glass, Not affected by acids. Chem. com. $2\ddot{A}i^2\ddot{S}i^3 + 3(\dot{C}a, \dot{F}e, \dot{M}g)\ddot{S}i + 3\dot{H}$. Analysis No. 3.

(*d.*) *Neurolite*, Thomson, from Stamstead in Lower Canada, is massive and fine columnar, H. = 4·25; G. = 2·47; translucent or opaque; colour greenish-yellow. B.B. infusible, but becomes snow-white and pulverulent; with soda forms a transparent glass. Chem. com. $2\ddot{A}i\ddot{S}i^6 + \dot{C}a\ddot{S}i^3 + 3\dot{H}$. Analysis No. 4.

(*e.*) *Onkosin*, v. Kobell, from dolomite, near Lungau in Salzburg, massive, fracture uneven, or splintery; sectile; H. = 2; G. = 2·8; Translucent; slightly resinous lustre; colour apple-green, greyish or brownish, B.B. intumesces and fuses to a white porous glass. Perfectly soluble in sulphuric, but not in hydrochloric acid. Chem. com. nearly $3\ddot{A}i\ddot{S}i^2 + (\dot{K}, \dot{M}g)^2\ddot{S}i^3 + 3\dot{H}$. Analysis No. 5.

	Silica.	Alumina.	Iron protox.	Lime.	Magnesia.	Potash.	Watr.	Total.	
1	33·48	31·85	26·01	2·46	...	...	5·28	99·08	Thomson.
2	40·50	11·41	23·91	19·78	...	...	4·35	99·35	Do.
3	45·90	33·92	4·32	8·04	1·72	...	4·16	97·96	Do.
4	73·00	17·35	0·40*a*	3·25	1·50	...	4·30	99·80	Do.
5	52·52	30·33	0·80	...	3·32	6·38	4·60	99·00	v. Kobell.

(*a*) Peroxide.

29. NEPHRITE, *Werner*, *Phillips*, *&c.*; Jade, *Hauy*; Uncleavable Adiaphane-spar, *Mohs.*

Only known in compact masses with a coarse splintery fracture. Very tenacious; H. = 6 — 6·5; G. = 2·9 — 3. Translucent. Lustre dull or resinous. Colour leek-green to greenish-white or blackish-green. Feels slightly greasy. B.B. some become white and melt with difficulty to a grey mass; others (as Nos. 5, 6,) intumesce and melt slowly to a white enamel. Analyses.

	Silica.	Magnesia.	Lime.	Iron.	Manganese.	Alumina.	Potash.	Watr.	Total.	
1	54·68	26·01	16·06	2·15*a*	1·39*a*	...	...	0·68	100·97	Rammelsberg.
2	58·91	22·42	12·28	2·70*b*	0·91*b*	1·32	0·80	0·25	99·59	Schafhäutl.
3	58·88	22·39	12·15	2·81*b*	0·83*b*	1·56	0·80	0·27	99·69	Do.
4	58·46	27·09	12·06	1·15*a*	...	...	...	...	98·76	Damour.
5	59·02	27·19	11·82	1·12*a*	...	...	...	...	98·15	Do.
6	50·50	31·00	...	5·50*b*	0·05*c*	10·00	...	2·75	99·80	Kastner.
7	41·69	34·63	4·25	1·75*b*	...	0·56	...	13·42	96·30	Bowen.

(*a*) Protoxide; (*b*) peroxide; (*c*) chrome oxide.

No. 1 from Turkey was determined as nephrite by Breithaupt; No. 2 was cut into an amulet; No. 3 into a ringstone, both from the east, G. = 2·96; Nos. 4, 5 were milk-white oriental jade; G. = 2·97.

These analyses give rather discordant results. No. 1 resembles augite, whereas Nos. 2–5 are exactly the composition of white tremolite. It is thus probable that nephrite is merely a peculiar condition of augite and hornblende. It comes chiefly in a manufactured state from Turkey and the east. In China it is much valued for its supposed medical properties, and is cut into various ornaments and amulets. It was also used by the ancient Egyptians; and the natives of New Zealand fashion a similar stone, the Poenamu, into axes and other weapons. No. 6, an old analysis, is a wholly distinct mineral. No. 7, from the primary limestone, of Smithfield Rhode Island, is of a fine sky-blue colour, and, if pure, also distinct.

IV. Family.—Haloid Stones.

30. **Lazulite**, *Karsten*, *Werner*, *Hauy*, *&c.*; Azurite, *Phillips;* Klaprothine, *Beudant*, *Dufrénoy;* Blauspath, *Werner;* Prismatic Azure-spar, (Lazurspath), *Mohs* and *Jameson.*

Rhombic; ∞P 91° 30′, $\breve{P}\infty$ 59° 20′, $\bar{P}\infty$ 58° 30′. The crystals, formed predominately by the acute pyramid P and the above three prisms, somewhat resemble those of sulphur, but are extremely rare. Usually it occurs massive or disseminated in distinct granular aggregates. Cleavage, probably prismatic along ∞P, imperfect; fracture uneven, splintery; H. = 5 — 6; G. = 3 — 3·1. Translucent on the edges; lustre vitreous; colourless, but almost constantly coloured indigo, smalt, or other shades of blue inclining to green or white. Streak white. In closed tube yields water and loses its colour. B.B. intumesces, but does not melt. With cobalt solution assumes a fine blue colour. Colours the flame slightly green. Scarcely affected by acids till after ignition, when almost wholly soluble. Chem. com. according to Rammelsberg, $[2(\dot{M}g, \dot{F}e)^3 \dddot{P} + \ddot{A}l^4\dddot{P}^3] + 6\dot{H}$ or a hydrous combination of a phosphate of alumina and a phosphate of magnesia and protoxide of iron. Analyses.

	Phosphoric acid.	Alumina.	Magnesia.	Iron protox.	Lime.	Water.	Total.	
1	41·81	35·73	9·34	2·64	...	6·06*a*	97·68	Fuchs.
2	42·41	29·58	10·67	10·60	1·12	5·62	100	Rammelsberg.
3	43·04	33·09	9·00	6·69	1·44	5·94	100	Do.
4	46·99	27·62	11·19	6·47	2·12	5·61	100	Do.
5	41·33	32·68	9·54	9·54	0·77	6·14	100	Do.
6	47·04	26·92	10·67	7·84	1·21	6·32	100	Do.
7	40·95	36·22	12·85	1·64	1·42	6·92	100	Do.
8	47·36	30·05	12·20	1·89	1·65	6·85	100	Do.
9	47·73	27·48	12·16	1·91	4·32	6·40	100	Do.

(*a*) + 2·10 Silica.

1, from Rädelgraben, Salzburg; 2–6, dark-blue lazulite from the Fischbacher Alp, near Gratz, Styria, G. = 3·11; 7–9, light-coloured blue spar from Fressnitzgraben, near Krieglach in Styria, G. = 3·02.

In Rammelsberg's analyses the silica considered as a mixture is first abstracted. It amounted to 0·53 in No. 1, 4·44 in No. 2, 6·64 in No. 8, and 12·56 per cent. in No. 9. R. remarks that in the first member of the formula the phosphoric acid is in the same state of saturation as in the wagnerite and vivianite, whilst the second represents the chief constituent of the wavellite.

The lazulite occurs in small veins with quarz and carbonate of iron, in clayslate in the torrent beds of the Schlamming and Rädelgraben near Werfen in Salzburg. Also it is said at Waldbach near Vorau in Styria, whence named the *Voraulite*. The blue spar is found in large blocks, or rarely indistinct crystals with quarz and mica, near Krieglach in Upper Styria, and at the foot of the Wechsel, near Therenberg, in Lower Austria. Also crystallized and massive at Tijuco in Minas Geraes, Brazil.

31. CALAITE, *von Waldheim, Phillips, &c.*; Callais, *Pliny*; Mineral Turquois, *Jameson*; Türkis, *von Leonhard*; Uncleavable Azure-spar, *Mohs.*

Amorphous, reniform, stalactitic, or encrusting. Fracture conchoidal or uneven, H. = 6; G. = 2·62 — 2·8. Opaque or feebly translucent on the edges; lustre dull or waxy; colour skye-blue, greenish-blue, rarely pistachio or apple-green; streak greenish-white. In the closed tube yields water, decrepitates violently, and becomes black. B.B. infusible, but colours the flame green; with borax and salt of phosphorus, shows reaction for copper and iron. Soluble in acids Chem. com. $\dddot{\mathrm{Al}}^2\dddot{\mathrm{P}} + 5\,\dot{\mathrm{H}}$ = 46·89 alumina, 32 57 phosphoric acid and 20·54 water, but mixed with a little phosphate of iron and copper. Analyses.

	Phosphoric acid.	Alumina.	Watr.	Copper protox	Iron perox.	Mangan perox.	Phosphate of Lime.	Total.	
1	30·90	44·50	19·00	3·75	1·80*a*	...	..	99·95	John.
2	38·90	54·50	1·00	1·50	2·80	...	...	98·70	Zellner.
3	27·34	47·45	18·18	2·02	1·10	0·50	3·41	100	Hermann
4	5·64	50·75	18·13	1·42	1·10	0·60	18·10*b*	100	Do.
5	29·03	38·47	27·50	0·80	1·20		3·00*c*	100	Do.
6	30·49	44·49	22·82		2·20*c*		...	100	Do.

(*a*) Protoxide; (*b*) + 4·26 silica; (*c*) with veinstone.

The composition of this mineral seems far from uniform; but the above formula corresponds with No. 1, and, though less exactly, with 3 and 6. In No. 2 the proportion of phosphoric acid to alumina is nearly the same, so that it is perhaps the anhydrous mineral The green variety, No. 4, seems a very uncertain mixture.

It occurs in fissures in flinty slate at Jordansmühle in Silesia (Nos. 1 and 2), in the Lausitz, and in the Voigtland, and in clayslate, near Striegau. The Oriental turquoise, No. 3, azure blue, G. = 2·621, and No. 4, green, is said to occur in veins, but chiefly in pebbles in alluvium in Persia, as at Nichabur in Khorazan, and in Bucharia; and recently also in the Syrian desert. It takes a fine polish, and is valued as an ornamental stone; the King of Persia, it is said, retaining the finer specimens for his own use. Some fossil teeth and bones, coloured by hydrated copper-oxide, or phosphate of iron, from Miask in Siberia and Trevaux in France, are often substituted for this mineral.

The *Fischerite* of Hermann (No. 5 of anal.) is a green mineral from Nischnei Tagilsk, where it occurs in crystalline crusts or small indistinct six-sided prisms, H. = 5; G. = 2·46. It is only slightly soluble in muriatic or nitric, but wholly in sulphuric acid: and on heating becomes white or partly black. It seems $\ddot{A}i^2\ \ddot{P} + 8\dot{H}$, or $(\ddot{A}i^4\ddot{P}^3 + 18\dot{H}) + 2\ddot{A}i\ \dot{H}^3$ that is, a combination of wavellite (with no fluorine) and of gibbsite.

The *Peganite* of Breithaupt (No. 6), from Strigis in Saxony, usually classed with wavellite, agrees with the above in chemical character, its composition being $\ddot{A}i^2\ \ddot{P} + 6\dot{H}$. It is probably rhombic (∞P 127° nearly), and occurs in very small prismatic crystals, formed by ∞P . 0P . $\infty\breve{P}\infty$. These are united in thin crusts, of an emerald, grass-green, or white colour, H. = 3 — 4; G. = 2·49 — 2·54. As Rammelsberg observes, calaite, fischerite, and peganite are thus various hydrates of one and the same phosphate of alumina.

The *Variscite* of Breithaupt, forming a green reniform incrustation, with weak resinous lustre and greasy feel, on flinty slate at Messbach, near Plauen, in the Voigtland, seems a similar compound. In the closed tube it yields much water, and assumes a rose-red colour. B.B. in the forceps colours the exterior flame intense bluish-green, becomes white, but is infusible; with borax forms a yellowish-green glass; with cobalt solution becomes blue. Plattner considers it as chiefly composed of alumina and phosphoric acid, with water, ammonia, magnesia, protoxide of iron, and chrome-oxide.

(32.) WAVELLITE, *Jameson*, *Werner*, *Phillips*; Lasionite, *Fuchs*; Devonite, *Thomson*; Alumine Phosphatée, *Hauy*; Prismatic Wavelline Haloid, *Mohs*.

Rhombic (microcrystalline), ∞P 126° 25′, $\bar{P}\infty$ 106° 46′, usual combination $\infty\breve{P}\infty\ (P) . \infty P(d) . \bar{P}\infty\ (o)$ fig. 113; but the crystals generally small, acicular, and united in minute hemispherical masses, with a

radiated fibrous texture and drusy surface. Cleavage, along ∞P and Fig. 113. $\breve{P}\infty$ rather perfect, H.= 3·5 — 4; G.= 2·3 — 2·5. Trans-

lucent; vitreous lustre; colourless, but generally yellowish or greyish, sometimes a beautiful green or blue In closed tube yields water, often with traces of fluoric acid. B.B. in the forceps colours the flame weak bluish-green; on charcoal intumesces, and becomes snow-white; with cobalt solution blue. Soluble in acids, and in warm sulphuric acid often with evolution of fluoric acid. Chem. com. essentially $\ddot{A}l^3\,\ddot{P}^2 + 12\dot{H}$ with 38·0 alumina, 35·3 phosphoric acid, and 26·7 water; but Berzelius proposes $\ddot{A}l\,Fl^3 + 3(\ddot{A}l^4\,\ddot{P}^3 + 18\dot{H})$. Analyses.

	Alumina.	Phosphoric acid.	Water.	Fluoric acid.	Iron perox.	Lime.	Silica.	Total.	*
1	37·18	34·98	28·00	...	...	...	...	100·16	Fuchs (M. of 2)
2	35·35	33·40	26·80	2·06	1·25*a*	0·50	...	99·36	Berzelius.
3	36·60	34·06	27·40	traces	1.00	...	...	99·06	Erdmann.
4	36·39	33·28	27·10	traces	2·69	...	...	99·46	Do.
5	34·90	31·55	24·01	traces	2·21	...	7·30	99·97	Do.
6	35·39	32·46	24·00	traces	1·50	...	6·65	100·00	Do.
7	10·01	17·86	25·95		36·32	0·15	8·90	99·19	Steinman.
8	11·29	9·20	18·98		36·83	..	3·30*b*	99·70	Holger.
9	...	20·5	30·2		43·1	1·1	2·1*c*	97·9	Richardson.
10	36·39	34·29	26·34	1·69*d*	1·20	..	...	99·91	Hermann.

(*a*) With peroxide of manganese; (*b*) +7·58 magnesia, 1·23 zinc-oxide, and 11·29 sulphuric acid; (*c*) + 0·9 magnesia; (*d*) fluorine.

From (1, 2) Barnstaple, Devonshire; (3, blue, 4, green and yellow, 5, brown, 6, black, varieties) Langen Striegis, near Freiberg; (7, 8, 9, 10) Zbirow, near Beraun, in Bohemia.

This mineral, named from Dr Wavel, its discoverer, occurs in small veins and fissures, sometimes in clayslate and other older rocks, as in various places near Beraun in Bohemia; at Frankenberg and Langen Striegis, Saxony, Tanne in the Harz, Barnstaple in Devonshire, near Clonmell and Cork, Ireland, and in the Shiant Isles in Scotland; in granite at Stenna Gwyn, near St Austle, Cornwall, and Roxborough in Pennsylvania; in secondary formations, at Amberg in Bavaria, and near Newcastle in England. Also near Saxton's River, New Hampshire, and Nashville, Tennessee in North America. The so-called wavellite from Villa Ricca is shown by von Kobell to be Hydrargillite. This chemist states, that the surest method to distinguish the phosphates from the hydrates of alumina, is to add acetic acid to the solution in muriatic acid, till ammonia produces no precipitate; if sulphate of magnesia and sal-ammoniac be now added, wavellite and other phosphates of alumina give a precipitate, the hydrates of alumina none.

Kakoxene (analyses 7, 8, 9) is by some regarded as a distinct mineral, and (Nos. 7 and 9) when the alumina and silica are abstracted.

as mixtures, give nearly the formula $\dot{F}e^2\,\ddot{P} + 12\dot{H}$. No. 10 of the mineral from the same locality corresponds, however, with wavellite, and the others are evidently from impure specimens.

33. WAGNERITE, *Fuchs, Phillips;* Fluophosphate of Magnesia, *Thomson;* Magnésie phosphatée, *Dufrénoy;* Hemiprismatic Dysthom-spar, *Mohs.*

Monoclinohedric, C = 63° 25′, ∞P 57° 35′, ·P∞ 71° 53′. The crystals form very complex combinations, and appear like short prisms with vertical striæ. Cleavage prismatic along ∞P, and orthodiagonal imperfect, also traces along 0P. Fracture conchoidal or splintery; H. = 5—5·5; G. = 2·985 opaque, 3·068 transparent crystals (Rammelsberg). Translucent or transparent; lustre resinous, inclining to vitreous; colour wine-yellow, honey-yellow, and white. B.B. fuses with great difficulty in thin splinters to a dark-greenish grey glass. Moistened with sulphuric acid, colours the flame weak bluish-green. Powder slowly soluble, with escape of fluoric acid, in warm nitric and sulphuric acids. Chem. com. $\dot{Mg}^3\,\ddot{P} + \dot{Mg}\,Fl$ with 43·32 phosphoric acid, 11·35 fluorine, and 37·64 magnesia, and 7·69 magnesium. In analysis 50·38 magnesia will be found. Analyses.

	Magnesia.	Iron perox.	Manga. perox.	Phospho-ric acid.	Fluoric acid.	Lime.	Silica.	Total.	
1	46·66	5·00	0·50	41·73	6·50	...	...	100·39	Fuchs.
2	45·07	4·47*a*	...	39·56	9·12*b*	2·32	2·68	103·22	Rammelsberg.
3	46.27	4·59*a*	...	40·61	9·36*b*	2·38	...	103·22	Do.
4	1·49	1·41*c*	...	1·87	...	2·58	93·81	101·16	Do.

(*a*) Protoxide; (*b*) fluorine; (*c*) alumina and iron peroxide.

This mineral is very rare, having only been found in irregular veins with quarz in clayslate in the Höllgraben, near Werfen in Salzburg. No. 2 is the original analysis, No. 3 the same after rejecting the silica arising from incidental mixture, to which some other elements should also be ascribed. No. 4 is a soft reddish mineral found with it, and probably wagnerite, decomposed and replaced by silica.

34. AMBLYGONITE, *Breithaupt, Phillips, &c.;* Prismatic Amblygon-spar, *Mohs.*

Rhombic; in coarse granular masses. Cleavage prismatic along ∞P 106° 10′ tolerably perfect; brachydiagonal imperfect. Fracture uneven and splintery; H. = 6; G. = 3 — 3·1. Translucent, lustre vitreous, pearly on ∞P, on fracture surfaces inclining to resinous. Colour greyish or greenish-white, to pale mountain-green. In closed tube yields water sometimes corroding the glass. B.B. fuses very

readily to a transparent glass, becoming opaque when cold. Colours the flame rather yellow than red; but moistened with sulphuric acid bluish-green. Finely pulverized it is soluble slowly in hydrochloric acid, more readily in sulphuric acid. Chem. com. according to Rammelsberg, $(\ddot{Al}^5\ddot{\dot{P}}^3 + \dot{R}^5\ddot{\dot{P}}^3) + (Al\,F^3 + RF)$ in which R is lithium and sodium. Analyses.

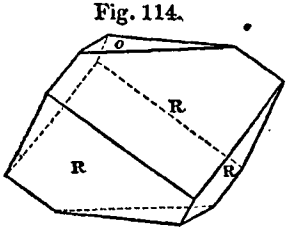
	Phosphoric acid.	Alumina.	Lithia	Soda.	Potash.	Fluorine.	Aluminium.	Lithium	Sodium.	Total.
1	48·00	36·26	6·33	5·48	Undet.	...	...	...	...	...
2	47·15	38·43	7·03	3·29	0·43	...	...	...	...	...
3	48·00	30·69	5·21	4·51	...	8·11	2·97	0·50	0·72	100·71
4	47·87	34·46	6·90	5·98	...	8·36	...	...	...	103·57

These analyses by Rammelsberg are (1, 2) actual results, the fluorine being found by another trial. No. 3 is No. 1 according to his interpretation of its composition; and No. 4 is the amount which by the formula analysis should give. This mineral is found in veins in granite at Chursdorf and Arnsdorf near Penig in Saxony, with turmaline, topaz, and other minerals. Also, it is said, at Arendal in Norway, with garnet and augite.

35. ALUNITE, *Cordier, Dufrénoy;* Alumstone, *Phillips, &c.;* Alaunstein, *Werner;* Rhombohedral Alum Haloid, *Mohs.*

Rhombohedric; R 92° 50′; the crystals are almost constantly either R, or R . 0R (fig. 114); they are small, often with curved faces, and combined in groups or druses. It very frequently occurs in minute or fine granular, earthy or compact masses, intimately mixed with quartz or felspar. Cleavage basal, rather perfect. H. = 3·5 — 4; G. = 2·6 — 2·8. Translucent; lustre vitreous, on 0R pearly. Colourless and white, but coloured greyish, yellowish, or reddish. B.B. infusible alone. With borax forms a colourless glass. Becomes blue with cobalt solution. Soluble in warm concentrated sulphuric acid: not affected by hydrochloric acid. Water extracts alum from the ignited mineral. Analyses.

Fig. 114.



	Sulphuric acid.	Alumina.	Potash.	Water.	Silica.	Iron perox.	Total.	
1	12·50	17·50	1·00	5·00	62·25	...	98·25	Klaproth, Hungary.
2	27·00	31·80	5·80	3·72	28·40	1·44	98·16	Cordier, Mont Dore.
3	35·6	40·0	13·8	10·6	...	...	100	Descotils, Montione.
4	35·50	39·65	10·02	14·83	...	...	100	Cordier, Tolfa.
5	27·0	26·0	7·3	8·2	26·5	4·0	99·0	Berthier, Hungary.
6	39·42	37·95	10·66	11·97	...	...	100	Do. Do.

The compact varieties (1, 2) are evidently mixtures, and can furnish no formula. Nos. 5 and 6 are the same analysis, the latter with the impurities abstracted. It gives nearly 3 $\ddot{A}\dot{s} + \dot{K}\dot{s} + 6\dot{H}$, whilst that of Cordier, No. 2, agrees better with $\ddot{A}\dot{s}^4 + \dot{K}\dot{s} + 8\dot{H}$.

Alunite is found massive in Hungary, at Beregszasz (Nos. 1, 5), and Muzay; and at Tolfa near Civitá Vecchia in the Papal States, in distinct crystals. It also occurs in Tuscany, near Naples, in the crater of Volcano, one of the Lipari islands, in loose blocks in Auvergne, and in the Greek islands of Milo and Argentiera. The Roman alum, valued on account of its purity, is chiefly obtained from this mineral by repeated roasting and lixiviation. Berthier explains the singular change produced in this substance by ignition from an alteration in the grouping of the atoms. In volcanic regions it is often formed by the action of sulphurous vapours on trachyte, and in other felspar rocks, by the decomposition of iron pyrites.

36. ALUMINITE, *Jameson*, *Mohs*; Subsulphate of alumina, *Phillips*; Websterite, *Lévy*, *Dufrénoy*.

Cryptocrystalline; only in reniform masses, with a very fine scaly or fibrous structure. Fracture earthy; sectile or friable; H. = 1; G. = 1·7. Opaque; lustre dull or glimmering; colour snow-white or yellowish-white. In closed tube yields much water. B.B. on ignition emits sulphurous fumes, the remainder being infusible, and acting like alumina. Easily soluble in hydrochloric acid. Chem. com. of purest varieties, $\ddot{A}\dot{s} + 9\dot{H}$, with 29·8 alumina, 23·2 sulphuric acid, and 47 water. Analyses.

	Alumina.	Sulphuric acid.	Water.	Total.	
1	29·87	23·37	46·76	100	Stromeyer, Newhaven.
2	30·26	23·37	46·37	100	Do. Halle.
3	30·98	23·68	45·34	100	Do. Morl.
4	29·23	23·25	46·34 *a*	100	Schmid, Halle.
5	30·7	22·3	47·0	100	Marchand, do.
6	29·72	23·45	46·80	99·97	Dufrénoy, Lunel Vieil.
7	30	23	47	100	Dumas, Auteuil.
8	39·50	11·45	48·80	99·75	Marchand, near Halle.
9	36·0	17·0	47·2	100·2	Do. do.
10	36·17	14·54	49·03	99·74	Schmid, do.

(*a*) + 1·18 lime.

This mineral seems of recent origin, from the decomposition of the clay in which it is found, as at Newhaven in Sussex, Epernay, Auteuil, and Lunel Vieil in France; at Halle and Morl in Prussia. Nos. 8, 9, 10, are analyses of a substance found south from Halle, of a similar character, and probably aluminite mixed with a hydrate of alumina; or,

No. 8, = 2 aluminite + 3 $\ddot{A}\dot{l}\,\dot{H}^6$; No. 9, = 3 aluminite + 2 $\ddot{A}\dot{l}\,\dot{H}^4$, $\dot{H}$; and No. 10, = 1 aluminite + $\ddot{A}\dot{l}\,\dot{H}^6$.

37. Pissophane, *Breithaupt.*

Stalactitic and massive; fracture conchoidal; rather sectile, and very easily frangible. H = 2; G = 1·92 — 1·98. Transparent or translucent; lustre vitreous. Colour olive-green to liver-brown; streak greenish-white to pale yellow. B.B. becomes black, and, with fluxes shows reaction for iron. Easily soluble in hydrochloric acid. Analyses.

	Sulphuric acid.	Alumina.	Iron perox.	Water.	Veinstone and Loss.	Total.	
1	12·70	35·15	9·74	41·69	0·72	100	Erdmann, green var.
2	12·49	35·30	9·80	41·70	0·71	100	Do. do.
3	11·90	6·80	40·06	40·13	1·11	100	Do. yellow stalac

Nos. 1, 2 give $\ddot{R}^5\,\ddot{S}^2 + 30\,\dot{H}$; whereas $\ddot{R}^2\,\ddot{S} + 15\,\dot{H}$, agrees better with No. 3. It is probably a mixture of several salts formed from the decomposition of alumslate, in which it occurs at Garnsdorff near Saalfeld (anal. 1–3), and at Reichenbach in Saxony. It is still forming, exuding in syrup-like drops, which gradually harden to a horny consistence.

38. Latrobite, *Brooke;* Diploite, *Breithaupt.*

Triclinohedric; in indistinct prismatic crystals; but mostly massive and disseminated. Cleavage in three directions, intersecting at 91°, 93° 30′, and 98° 30′. Fracture uneven. H. = 5 — 6; G. = 2·7 — 2·8. Translucent; vitreous; colour peach-blossom or rose-red, and reddish-white. B.B. becomes white, intumesces, and melts on the edges to a porous mass. With soda on platinum wire shows traces of manganese. In borax melts to a clear glass. Chem. com. perhaps 4 $\ddot{A}\ddot{i}\ddot{s}i + 2\,\dot{c}a\,\ddot{s}i + \dot{k}\,\ddot{s}i$. Analyses.

	Silica.	Alumina.	Lime.	Potash.	Mang. perox	Magnesia.	Watr.	Total.	
1	44·65	36·81	8·28	6·59	3·16	0·63	2·04	102·16	C. G. Gmelin.
2	41·78	32·83	9·79	6·58	5·77		2·04	98·79	Do.

Found with felspar, mica, and calc-spar at Amitok island (No. 1, 2) in Labrador, and also, it is said, at Bolton, Massachusetts. Breithaupt joins the amphodelite to this species, but it is rather a variety of anorthite.

V. Family.—Leucite.

39. Leucite, *Werner, Phillips;* Amphigene, *Hauy;* Trapezoidal Amphigene-spar, *Mohs.*

Tesseral; only 202 (fig. 6 above) yet observed. The crystals are generally single, and with all their faces formed; more rarely in groups or granular aggregates. Cleavage hexahedral, but very imperfect. Fracture conchoidal. H. = 5·5 — 6; G. = 2·4 — 2·5. Transparent to translucent only on the edges. Lustre vitreous, inclining to resinous. Colourless, but coloured greyish, yellowish, or reddish-white, or grey; streak white. B.B. infusible alone; with borax difficultly to a clear glass; with cobalt solution becomes blue. Soluble in hydrochloric acid without gelatinizing. Chem. com. $\dot{A}\ddot{i}\,\ddot{s}i^{8} + \dot{K}\ddot{s}i$, with 55.7 silica, 23·1 alumina, and 21·2 potash. Analyses.

	Silica.	Alumina.	Potash.	Soda.	Iron perox.	Lime.	Total.	
1	53·75	24·63	21·35	...	...	...	99·73	Klaproth, Vesuvius.
2	54·50	23·50	19·50	...	...	...	97·50	Do. Pompeii.
3	56·10	23·10	21·15	...	0·95	...	101·30	Arfvedson, Vesuvius.
4	56·05	23·03	20·40	1·02	...	trace.	100·50	Awdejew, Somma.

This mineral is remarkable as the one in which Klaproth first discovered that potash was a constituent of the mineral kingdom. According to Sir D. Brewster, it possesses two axes of double refraction, and is consequently one of the few exceptions to the optical laws prevailing in the system of crystallization to which it belongs.

It is frequently associated with augite, and is abundant in the lavas of Vesuvius, the tufas near Rome, and the peperino of Albano. At Rieden, near Lake Laach on the Rhine, it occurs in a crystalline mixture with glassy felspar, nosean, augite, &c. The larger crystals (as in the lava of Borghetta) often enclose portions of lava or small crystals of augite, which shows, according to v. Buch, that the leucite has been formed from the lava during its cooling.

40. Procelain Spar, *Fuchs, Mohs.*

Rhombic; ∞P 92° nearly. Occurs massive and distinctly coarse granular. Cleavage brachydiagonal, rather perfect, also macrodiagonal. Fracture uneven. H. = 5·5; G. = 2·67 — 2·68. Translucent, or only on the edges. Lustre vitreous, or pearly on the cleavage planes. Colour yellowish or bluish-white, or pale grey. B.B. fuses easily with intumescence to a colourless vesicular glass. Soluble without gelatinizing in concentrated hydrochloric acid. Analyses.

	Silica.	Alumina.	Lime.	Soda.	Potash.	Water.	Chlorine.	Total.	
1	49·30	27·90	14·42	5·46	...	0·90	...	97·98	Fuchs.
2	50·29	27·37	13·53	5·92	0·17	...	...	97·30	v. Kobell.
3	49·20	27·30	15·48	4·53	1·23	1·20	0·92	99·66	Schafhäutl.

According to a more recent analysis of Fuchs, this mineral contains 7·83 per cent. chloride of sodium, and may be represented by 4 $\dot{A}i\ \dot{s}i^3$ + 4 $\dot{C}a\ \dot{s}i$ + Na Cl = 49·72 silica, 27·48 alumina, 14·97 lime, and 7·83 chloride of sodium. Schafhäutl states that the whole chloride is volatile at a strong red heat. It occurs at Obernzell near Passau, either massive in a bed in granite, or loose and crystallized in the mines of porcelain earth.

41. SODALITE, *Thomson*, *Hauy*, *Phillips*, *&c.*; Dodecahedral Amphigene-spar, *Mohs*.

Tesseral; ∞O (fig. 3). Also massive and distinct granular. Cleavage dodecahedral along ∞O, more or less perfect. Fracture conchoidal or uneven. H. = 5·5; G. = 2·28 — 2·29. Translucent. Lustre vitreous, inclining to resinous. Colourless, but coloured in various shades of white, grey, green, and rarely blue. B.B. becomes white and fuses easily alone, sometimes intumescing, to a clear glass; with difficulty in borax. Gelatinizes with acids. Chem. com. 3 $\dot{A}i\ \dot{s}i$ + 3 $\dot{N}a\ \dot{s}i$ + Na Cl = 37·8 silica, 33·3 alumina + 25·3 soda, and 5·6 chlorine. Analyses.

	Silica.	Alumina.	Soda.	Lime.	Iron perox.	Muriatic acid.	Total.	
1	36·00	32·00	25·00	...	0·15	6·75	99·90	Ekeberg, Greenland.
2	38·52	27·48	23·50	2·70	1·00	3·00 *a*	98·30	Thomson, do.
3	44·87	23·75	27·50*b*	...	0·12	3·76	100	Borkowsky, Vesuvius.
4	33·75	35·50	26·23	...	...	5·30	100·78	Arfvedson, do.
5	38·40	32·04	24·47	0·32	...	7·30	102·53	Hofmann, Ilmen M.
6	37·30	32·88 *c*	23·86	0·59*d*	...	6·97 *e*	100·60	Whitney, Litchfield.
7	37·63	30·93	25·48	...	1·08	...	...	Do. do.

(*a*) + 2·10 volatile matter; (*b*) with potash; (*c*) with iron perox.; (*d*) potash; (*e*) chlorine.

Occurs in Greenland, in a bed in mica slate, along with felspar and eudialyte, and is pink when newly fractured, but becomes green on exposure. On Vesuvius of a white colour, in ejected dolomite blocks with nepheline, ryacolite, mica, hornblende, and garnet; more rarely in recent lava on Vesuvius; also in the Valle di Noto in Sicily, and near Lake Laach. In the Ilmen hills Ural, in miascite with felspar and nepheline; at Fredriksvärn in Norway, and more recently, of a blue colour from iron, at Litchfield in Maine.

According to Mr Whitney it forms (like cancrinite, hauyne, nosean, and nepheline) a clear solution in acids, and consists of ($\dot{N}a\ \dot{s}i$ + 3 $\dot{A}i\ \dot{s}i$), + Na Cl.—the first member being common to all these minerals.

42. HAUYNE, *Neergaard, Hauy, Phillips;* (with nosean) Dodecahedral Amphigene-spar, *Mohs.*

Tesseral; chiefly ∞O, but more common in crystalline grains; mostly disseminated singly. Cleavage dodecahedral along ∞O, more or less perfect. H. = 5 — 5·5; G. = 2·4 — 2·5. Semitransparent or translucent; lustre vitreous or resinous; colour azure or sky blue; streak bluish-white. B.B. decrepitates violently, and melts to a bluish-green vesicular glass. Soluble in hydrochloric acid to a clear fluid, with scarce a trace of sulphuretted hydrogen. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Soda.	Potash.	Sulphuric acid.	Total.	
1	35·48	18·87	1·16	12·06	...	15·45	12·39 *a*	100	L. Gmelin.
2	35·01	27·42	0·17 *b*	12·55	9·12	...	12·60 *c*	98·34	Varrentrapp.
3	32·44	27·75	...	9·96	14·24	2·40	12·98	99·77	Whitney.
4	33·90	28·07	...	7·59	19·23	...	12·01	100·76	Do.
5	34·83	28·51	0·31	7·23	18·57	...	12·13	101·58	Do.

(*a*) + 3·45 sulphuretted hydrogen and loss; (*b*) iron; (*c*) + 0·24 sulphur, 0·58 chlorine, 0·62 water.

From (1) Marino; (2, 4, 5) Niedermendig; (3) Mont Albano.

The analyses do not very well agree, but the formula $(\dot{N}a, \dot{K},)^2\ \ddot{S}i + \ddot{A}l^2\ \ddot{s}i^3 + \dot{C}a\ \ddot{S}$ = 34·8 silica, 28·9 alumina, 17·2 soda, 7·9 lime, and 11·2 sulphuric acid, represents them pretty nearly. Rammelsberg gives $[(\dot{N}a^3, \dot{K}^3,)\ \ddot{s}i + 3\ \ddot{A}l\ \ddot{s}i] + 2\ \dot{C}a\ \ddot{S}$ for the Mont Albano variety, and regards that from Niedermendig as mixed with sodalite.

This mineral is found in the ejected blocks on Vesuvius; in lava on Mount Vultur near Melfi, the Campagna of Rome, and Niedermendig near Andernach; in peperino at Albano and Marino. Also it is said in Auvergne and the Cantal in a basaltic or phonolite rock.

43. NOSEAN, *Klaproth;* Spinellane, *Hauy, Phillips.*

Tesseral; like hauyne in form and cleavage, but oftener in granular masses. H. = 5·5; G. = 2·25 — 2·27. Translucent or only on the edges; lustre vitreous, inclining to resinous; colour ash or yellowish-grey, sometimes blue, brown, or black. B.B. becomes paler, and melts on the edges to a vesicular glass. Soluble in acids, without any trace of sulphuretted hydrogen (Whitney). Analyses of the variety from Lake Laach.

	Silica.	Alumina.	Iron perox.	Lime.	Soda.	Sulphuric acid.	Chlorine.	Water.	Total.	
1	43·00	29·5	2·0	1·5	19·0	.. *a*	...	2·5	99·5	Klaproth.
2	38·50	29·25	1·50 *b*	1·14	16·56	8·16 *c*	...	...	99·11	Bergmann.
3	37·00	27·50	1·15 *b*	8·14	12·24	11·56 *d*	...	...	99·59	Do.
4	35·99	32·57	0·04 *e*	1·12	17·84	9·17	0·65	1·85	99·23	Varrentrapp.
5	36·52	29·54	0·44	1·09	23·12	7·06	0·61	1·37 *f*	100·34	Whitney.
6	36·53	29·42	0·44	1·62	22·97	7·13	0·61	1·37 *f*	100·09	Do.

(*a*) + 1·0 sulphur; (*b*) protoxide; (*c*) + 1·00 manganese protox., 3·00 sulphuretted hydrogen; (*d*) 0·50 mangan. prot., 1·50 sulph. hyd.; (*e*) iron; (*f*) loss by heat.

Whitney's analyses would give nearly 3 ($\dot{N}a\,\dot{S}i + \ddot{A}l\,\dot{S}i$) + $\dot{N}a\,\ddot{S}$, (or ($\dot{N}a^3\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i$) + $\dot{N}a\,\ddot{S}$, Rammelsberg), = 36·65 silica, 30·59 alumina, 24·82 soda, and 7·94 sulphuric acid.

Nosean occurs in various places near Andernach on the Rhine, as at Lake Laach, in loose blocks of a crystalline compound of glassy felspar, hornblende, augite, and magnetic iron; at Rieden in leucite-porphyry; and at Niedermendig and Mayen in the so-called millstone lava. The blue variety is perhaps hauyne, and a similar mineral in the pumice of Pleit, and the trass of Tonnisstein, is also not certainly determined to be nosean.

44. Ittnerite, *C. Gmelin, Phillips.*

Tesseral, but only found in coarse granular aggregates; cleavage, dodecahedral distinct. Fracture imperfect conchoidal; H. = 5·5; G. = 2·37 — 2·40. Translucent; resinous lustre; colour smoke, ash or dark bluish-grey. In the closed tube yields much water. B.B. fuses, with much effervescence and sulphurous smell to a vesicular opaque glass. In borax forms a clear glass. Does not form a clear solution, but gelatinizes in concentrated hydrochloric acid. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Soda.	Potash	Sulph. acid.	Chlorine.	Water.	Total.	
1	34·02	28·40	0·62	7·27	12·15	1·56	2·86	0·75*a*	10·76*b*	98·39	C. Gmelin.
2	35·69	29·14	...	5·04	12·57	1·20	4.62	1·25	9·83*c*	100	Whitney.

(*a*) Hydrochloric acid; (*b*) with sulphuretted hydrogen; (*c*) and loss.

The composition of this mineral is very complex, but Rammelsberg divides it into two compounds—one sodalite and water, the other a hauyne (with only half the sulphate of lime) and water. It is found in the dolerite of the Kaiserstuhl in the Breisgau. The water distinguishes it from all the similar compounds.

Sodalite, hauyne, nosean, and ittnerite agree in form, mode of occurrence, and other points, and the last three are often considered one species. They all contain the same double-silicate united in the first with Na Cl in the second with $\dot{N}a\,\ddot{S}$, in the third with 2 $\dot{C}a\,\ddot{S}$, whence the isomorphism of these latter substances might be inferred.

45. Lapis-Lazuli, *Wallerius, Phillips;* Lasurstein, *Werner;* Lazulite, *Haüy;* Sappheirus, *Theophrastus, &c.*

Tesseral; ∞O, but rarely distinct. Generally massive and in fine granular aggregates. Imperfect dodecahedral cleavage; H. = 5·5; G. = 2·38 — 2·42. Translucent on the edges; dull resinous or slightly-vitreous lustre; colour ultramarine or azure-blue of various intensity.

Streak light-blue. B.B. loses its colour and fuses readily to a white porous glass. In borax effervesces and forms a clear glass. In hydrochloric acid the powder speedily loses its colour, is dissolved and gelatinizes, evolving sulphuretted hydrogen. Chem. com. indeterminate. Analyses.

	Silica.	Sul. acid.	Alumina.	Soda	Lime	Magnesia.	Iron perox.	Chlorine.	Sulphur.	Watr.	Total.	
1	46·0	4·0	14·5	...	17·5	...	3 0	...	...	2·0*a*	97·0	Klaproth.
2	49·	2	11	8	16	2	4	...	trace	trace	92	L. Gmelin.
3	45·50	5·89	31·76	9·09	3·52	...	0·86*d*	0·42	0·95	0·12	98·11	Varrentrapp.
4	35·8	...	34·8	23·2	3·15	...	...	...	3·1	...	100·0	C. and D.
5	46 60	3·83	23·30	21·48	0·02	(1·75)*c*	1·06*d*	trace	1·69	...	99·73	Varrentrapp.

(*a*) + 10·0 carbonic acid; (*b*) = carbonate of lime; (*c*) potash; (*d*) iron.
1, 2, 3, mineral; 4, ultramarine prepared from stone, by Clément and Désormes; 5, artificial ultramine used in the porcelain manufactory at Meissen.

Found chiefly in granular limestone; as on the shore of lake Baikal, near granite. It is mostly brought from China, Thibet, and especially Badakschan in Tartary. It is used for ornamental purposes, and the preparation of ultramarine-blue. The colour both in it and the hauyne seems caused by some compound of sulphur, probably with iron. A mode of preparing the artificial colour was first discovered by Chr. Gmelin. According to Varrentrapp the colour becomes more intense with the amount of iron. The lapis-lazuli often contains scales of mica and iron pyrites—the gold scales noticed by the ancients in the sapphire.

46. EUDIALITE, *Stromeyer*, *Hauy*, *Phillips*; Rhombohedric Almandine-spar, *Mohs*.

Rhombohedric; R 73° 24′; usual combination R . 0R . ∞P2 . ½R, also massive and granular. Cleavage, basal distinct; along ½R (126° 13′) less distinct. Fracture uneven; H. = 5 — 5·5; G. = 2·84 — 2·95. Semitranslucent or opaque. Lustre vitreous. Peach-blossom to brownish-red. Streak white. B.B. fuses easily to a light-green opaque glass. In salt of phosphorus the silica intumesces so much that the bead loses its spherical form. Gelatinizes in hydrochloric acid. Analyses.

	Silica.	Zirconia.	Lime.	Soda.	Iron perox.	Manganese perox.	Muriatic acid.	Water or loss by heat.	Total.	
1	52·48	10·90	10·14	13·92	6·86	2·57	1·03	1·80	99·70	Stromeyer.
2	54·10	11·58	10 80	11·40	7·86	2·93	0·30	1·66*a*	101·55	Pfaff.
3	49 92	16·88	11·11	12·28	6·97*b*	1·15*b*	1·19*c*	0·3*d*	100·52	Rammelsberg.

+ 0·92 copper oxide; (*b*) protoxide; (*c*) chlorine; (*d*) + 0·65 potash.

Rammelsberg gives the rather complex formula,—Na Cl + 4 [2 (Ca, Na, Fe)^3 Si^2 + Zr.Si^2] ; but rejecting the chlorine as not essential, this becomes 2 R^{3}Si^2 + Zr Si^2. He also considers that in Stromeyer's analysis the iron and manganese should be taken as protoxide, (6·16 and 2·31), and the muriatic acid as 1·00 chlorine, whilst a portion of the zirconia was not separated from the silica. Pfaff thought he found a new metallic oxide in the silica (Tantaline); and Svanberg recently some new earths in the zirconia.

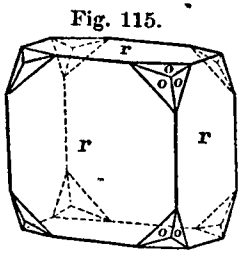
Eudialite has only been found at Kangerdluarsuk in Greenland in gneiss along with sodalite, arfvedsonite, and felspar. It much resembles almandine garnet, but is distinguished by its crystallization, lower specific gravity, inferior hardness, and action before the blowpipe.

VI. Family.—Zeolites.

47. Analcime, *Hauy*, *Phillips*, *Werner*, *&c.*; Hexahedral Kuphon-spar, *Mohs*.

Tesseral; generally 2O2, seldomer ∞O∞ . 2O2 (fig. 115). The crystals mostly united in druses; but also in granular masses. Cleavage hexahedal very imperfect. Fracture uneven. H. = 5·5; G. = 2·1 — 2·25. Transparent to translucent on the edges. Lustre vitreous, rarely pearly. Colourless, but white, greyish, greenish, yellowish, or reddish white; also flesh-red, and very rarely leek-green. In closed tube yields water, and becomes milk-white. B.B. melts quietly to a clear glass. Completely soluble and gelatinizes in hydrochloric acid. Chem. com. Al Si^3 + Na Si + 2H = 55·2 silica, 22·9 alumina, 13·9 soda, and 8 water. Analyses.

Fig. 115.



	Silica.	Alumina.	Soda.	Potash.	Lime.	Wtr.	Total.	
1	58·0	18·0	10·0	...	2·0	8·5	96·5	Vauquelin, Montecchio Maggiore.
2	55·12	22·99	13·53	...	...	8·27	99·91	H. Rose, Catania.
3	56·47	21·98	13·78	...	...	8·81	100·99	Do. Fassavalley.
4	55·07	22·23	13·71	...	...	8·22	99·23	Connel, Old Kilpatrick.
5	57·34	22·58	11·86	0·55	0·35	9·00	101·68	Henry, Blagodat.
6	55·60	23·00	14·65	...	...	7·90	101·15	Thomson, Giants' Causeway.
7	55·16	23·55	14·23	trace	trace	8·26	101·20	Awdejew, Lön, Brevig.
8	57·50	23·15	6·45	0·10*a*	5·63	8·00	100·83	Riegel, Niederkirchen.
9	56·12	24·00	6·45	0·15*a*	5·83	8·00	100·54	Do. Do.
10	51·27	23·56	5·13	7·31*a*	1·23*b*	10·55	99·05	Thomson, Kilpatrick Hills.

(*a*) Iron peroxide; (*b*) magnesia.

Chiefly found in amygdaloidal cavities or fissures in trap, basalt, or trachyte rocks. Fine large crystals occur in the Southern Tyrol (Seisser Alpe), near Dumbarton in Scotland, and at Almas and Tökerö in Siebenburg. Smaller crystals are found in the Cyclopean islands near Sicily, the Vicentine, in Faroe, Iceland, Nova Scotia, and also in the Hebrides, Glenfarg, Salisbury Craigs, and other parts of Scotland. More rare in the older rocks, as in drusy cavities of the zircon syenite of Laurvig and Brevig in Norway, in magnetic iron-ore at Arendal, and Blagodat in the Ural; and in the silver veins of Andreasberg in the Hartz. Sir D. Brewster states that when analcime crystals are divided into twenty-four equal parts, by planes passing through the centre parallel to the faces of the dodecahedron, each of these parts has a peculiar optical structure and double refraction. (Edin. R. S. Trans. x. 187.)

No. 3 has been named *Sarcolite*, but is only a variety as well as the *Cuboit* of Breithaupt (No. 5), massive, with distinct cleavage, greenish-grey, and G. = 2·24 — 2·28. The *Cluthalite* of Thomson (No. 10), from near Dumbarton, opaque and flesh-red, H. = 3·5, is also probably a connected species.

48. NATROLITE, *Werner;* Mesotype, *Hauy, Phillips, Levy, &c.;* Prismatic Kuphon-spar, *Mohs.*

Rhombic; ∞P 91°, P polar edges 143° 20′, and 142° 40′ (= 143° ± 20′), middle edges 53° 20′; generally only ∞P . P, seen fig. 116.

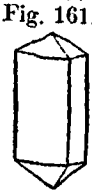


Fig. 161.

Crystals, fine prismatic, acicular or fibrous; united in reniform masses, sometimes apparently compact. Cleavage, prismatic along ∞P perfect; H. = 5 — 5·5; G. = 2·17 — 2·26. Translucent, or only on the edges; lustre vitreous; colourless, or greyish-white, but sometimes bluish, yellowish, or ochre-yellow, seldom red or brown. Is *not* pyro-electric. B.B. becomes obscure and melts quietly to a clear glass. Gelatinizes in hydrochloric acid, also perfectly dissolved by oxalic acid. Chem. com. $\ddot{A}l\,\dot{S}i^2 + \dot{N}a\,\dot{S}i + 2\,\dot{H}$; = 48 silica, 26·6 alumina, 16·1 soda, and 9·3 water. Analyses, next page.

Occurs chiefly in amygdaloid, basalt, dolerite, and clinkstone, either in veins, druses, or disseminated. More rarely in plutonic and primary rocks, as at Laurvig and Arendal. Fine crystals are found in Auvergne, and at Alpstein in Hessia; the yellow fibrous variety at Hohentwiel in the Högau. Common in various parts of Scotland, as in Mull, Canna, and near Tantallan Castle; and in Ireland, Nova Scotia, and other countries. The *Bergmannite* and *Radiolite* are merely varieties.

	Silica.	Alumina.	Soda.	Potash.	Lime.	Iron perox.	Water.	Total.	
1	47·76	25·88	16·21	...	...	...	9·31	99·16	Fuchs, Auvergne.
2	48·17	26·51	16·12	...	0·17	...	9·17	100·10	Do. do.
3	48·04	25·03	16·76	...	...	...	9·65	99·48	Thomson, do.
4	47·56	26·42	14·93	...	1·40	0·58	10·44	101·33	Do., Antrim.
5	47·21	25·60	16·12	...	...	1·35	8·88	99·16	Fuchs, Högau.
6	48·63	24·82	15·69	...	...	0·21	9·60	98·95	Do. Tyrol.
7	46·94	27·00	14·70	...	...	1·80	9·60	100·04	v. Kobell, Greenland.
8	47·34	27·21	14·61	...	1·34	...	9·47	99·97	Sander, Iceland.
9	48·05	25·80	15·75	...	...	2·10	9·00	100·70	Riegel, Högau.
10	47·97	26·66	14·07	trace.	0·63	0·73	9·77	99·88	Scheerer, Norway.
11	48·12	26·96	14·23	trace.	0·69	0·22	10·48	100·70	Do. do.
12	48·38	26·42	13·87	1·54	0·44	0·24	9·42	100·31	Do. do.

Nos. 1–4 are glassy; 5–9, fibrous natrolite; No. 10, flesh red, and 11, white bergmannite; No. 12, radiolite.

49. Scolezite, *Fuchs;* Needlestone, *Phillips;* Lime mesotype; Harmophane Kuphon-spar, *Mohs.*

Monoclinohedric, C = 90° 54′, ∞P 91° 35′, P 143° 29′, — P 144° 20′, usual combination ∞P . P . — P; crystals, short or long, prismatic or acicular. Twin crystals very common, united by a face of ∞P∞, and the chief axis also the twin axis, the two crystals forming apparently one individual (fig. 117.) Also massive, with radiating fibrous texture. Cleavage prismatic, along ∞P rather perfect; H. = 5 — 5·5; G. = 2·2 — 2·3. Transparent or translucent on the edges. Lustre vitreous, fibrous varieties silky. Colourless, but snow-white, greyish, yellowish, and reddish-white. It usually shows very distinct pyro-electricity, the diverging ends being antilogue, the converging analogue. B.B. bends and twists in a vermicular manner, and melts easily to a porous glass. In hydrochloric acid dissolves and gelatinizes; also soluble in oxalic acid, leaving oxalate of lime. Chem. com. $\ddot{Al}\,\ddot{Si}^2 + \dot{Ca}\,\ddot{Si} + 3\dot{H}$, with 46·6 silica, 25·8 alumina, 14 lime, and 13.6 water. Analyses.

Fig. 117.

	Silica.	Alum.	Lime.	Soda.	Water.	Total.	
1	49·0	26·5	15·3	...	9·0	99·8	Guillemin, Auvergne.
2	48·94	25·99	10·44	...	13·90	99·27	Fuchs and Gehlen, Iceland.
3	46·19	25·88	13·86	0·48	13·62	100·03	Do. Faroe.
4	47·00	26·13	9·35	5·47	12·25	100·20	Do. Do.
5	46·80	26·50	9·87	5·40	12·30	100·87	Berzelius, Do.
6	46·78	25·66	10·06	4·79	12·31	99 60	Fuchs and Gehlen, Iceland.
7	47·46	25·35	10·04	4·87	12·41	100·13	Do. Do.
8	46·04	27·00	9·61	5·20	12·36	100·21	Do. Tyrol.
9	46·75	24·82	14·20	0·39	13·64	99 80	Do. Staffa.
10	46·76	26·22	13·68	...	13·94	100·60	Gülich, Iceland.
11	46·72	25·90	13·71	...	13·67	100	Gibbs, do.
12	48·08	23·93	14·23	0·33	13·55	100·12	Riegel, Niederkirchen, (m. of 2).
13	48·88	26·36	7·64	4·20a	12·32	101·86	Thomson, Giants' Causeway.
14	46·00	27·60	15·20	...	14·35	103·15	Do. do.
15	48·03	26·66	5 47	8·32	11·72	100·20	Do. Kinross.
16	42·19	30·41	4·91	12·55	10·97	101·02	Do. Antrim.

(a) + 2·46 magnesia.

1–5, Crystalline; 6–10, fibrous varieties; (3–8) the mesolite of Fuchs.

Occurs in vesicular cavities in amygdaloid, basalt, and similar rocks, along with stilbite and other zeolites. Very fine specimens found in Staffa, at Berufiord in Iceland, in Faroe, Greenland, and the Vendyah Mountains in India. Also in Tyrol, Ireland, &c.

The mesolite of Fuchs appears from the researches of G. Rose to be in some cases a scolezite containing soda, in others natrolite, with lime, or perhaps a mixture of 2 atoms of the former mineral, with 1 of the latter. In a variety from the Giants' Causeway, Thomson found the interior portion (No. 13) different from the exterior (No. 14), the latter being scolezite, the former mesolite, and likewise an amount of magnesia, unexampled in this mineral. Nos. 15 and 16 by the same chemist also show some peculiarities, the latter especially in the proportion of silica.

The following minerals, sometimes described as distinct species, are either mere varieties of, or very closely allied to, scolezite or natrolite.

The *Caporcianite* of Savi, a reddish-grey, radiating fibrous mineral, from Caporciano, near Monte Catini in Tuscany. *Lehuntite* of Thomson, from amygdaloid Glenarm, Ireland, fine scalely flesh-red, G. = 1·953; H. = 3·75. *Poonahlite* of Brooke, forming rhombic prisms of 92° 20′, otherwise like scolezite, from Poonah in Hindostan. *Mesole* of Berzelius,—radiating, fibrous; transparent and pearly; white, yellow, or grey; G. = 2·35; H. = 3·5 — from Faroe, Schonen, &c. *Brevicite* of Berzelius,—radiated, massive, white, reddish-grey, or dark-red, in vesicular cavities of a plutonic (trachytic?) rock near Brevig. Yields water in the closed tube; B.B. melts to a clear porous glass. *Harringtonite*, Thomson,—compact, earthy, snow-white, from amygdaloid of Portrush, in Ireland. *Antrimolite*, Thomson,—white, fibrous, and opaque; G. = 2·096; H. = 3·75; from Antrim, Ireland. *Stellite*, Thomson,—crystallized apparently in fine rhombic prisms grouped in concentric stars. White, translucent, silky, H. = 3 — 3·5: G. = 2·612. From greenstone, eastwards from Kilsyth, Scotland. Analyses of these as follows.

	Silica.	Alum.	Lime.	Soda.	Potash.	Water.	Total.	
1	52·8	21·7	11·3	0·2	1*a*	13·1*a*	100·7	Anderson, Caporcian*ite*.
2	47·33	24·00	1·52	13·20	...	13·60	99·65	Thomson, Lehuntite.
3	45·12	30·45	10·20	0·66	trace	13·39	99·81	C. Gmelin, Poonahlite.
4	42·60	28·00	11·43	5·63	...	12·70	100·36	Berzelius, Mesole.
5	42·17	27·00	9·00	10·19	...	11·79	100·15	Hisinger, do.
6	41·52	26·80	8·07	10·81	...	11·79	98·99	Do. do.
7	42·70	27·50	7·61	7·00	...	14·71	99·52	Thompson, do.
8	43·68	28·39	6·88	10·32	0·21*b*	9.63	99·31	Sondén, Brevicite.
9	44·84	28·48	10·68	5·56	...	10·28*d*	99·84	Thomson, Harringtonite.
10	43·47	30·26	7·50	0·19*c*	4·10	15·32*e*	100·94	Do. Antrimolite.
11	46·47	5·30	30·96	3·53*c*	5·58*b*	6·11	99·95	Do. Stellite.

(*a*) + 0·1 iron peroxide, 0·4 magnesia; (*b*) magnesia; (*c*) iron protoxide; (*d*) with trace of muriatic acid; (*e*) + 0·098 chlorine.

From (4) Faroe; (5, 6) Annaklef in Schonen; (7) Bombay.

50. DAMOURITE, *Delesse.*

Massive and fine foliated. H. = 1·5; G. = 2·7 — 2·8. Translucent on the edges; lustre pearly; colour yellowish-white. B.B. yields water, intumesces, becomes milk-white, and melts with difficulty to a white enamel. With cobalt solution becomes blue. Not affected by hydrochloric, but decomposed by sulphuric acid, leaving silica in the form of the scales. After ignition the acid has no effect. Analysis.

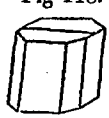
	Silica.	Alumina.	Potash.	Water.	Total.	
1	45·22	37·85	11·20	5·25	99·52	Damour, m. of 2.

This analysis gives the formula 3 $\ddot{A}i\,\dot{S}i$ + $\dot{K}\,\dot{S}i$ + 2 $\dot{H}$; or ($\ddot{A}i\,\dot{S}i^3$ + $\dot{K}\,\dot{S}i$) + 2 $\ddot{A}i\,\dot{H}$, of which the first part is orthoclase, the other diaspore. The action of the mineral with acids, so different from the zeolites of similar composition, seems to show that it is really a mixture. It occurs at Pontivy in Dpt. Morbihan in Brittany, forming the matrix of cyanite and staurolite. The mica slate of St Gotthardt, also enclosing these minerals, named *Paragonite* by Schafhäutl, is similar externally, but contains 50·20 silica, 35·90 alumina, 2·36 iron peroxide, 8·45 soda, and 2·45 water; and is infusible B.B.

51. THOMSONITE, *Brooke;* Comptonite, *Brewster;* Orthotomous and Peritomous Kuphone-spar, *Mohs.*

Rhombic, ∞P 90° 40′, the comptonite usually in the combination $\infty\breve{P}\infty$. $\infty\bar{P}\infty$. ∞P . $x\bar{P}\infty$, (fig. 118). $x\bar{P}\infty$ is an extremely obtuse dome of 177° 35′, and appears like the basis with the plane broken,—which is very characteristic of the crystals. In druses, fan-shaped and scopiform, or radiated aggregates. Cleavage, macrodiagonal and brachydiagonal, both equally perfect; H. = 5 — 5·5; G. = 2·3 — 2·4. Translucent, but often obscure. Vitreous, sometimes pearly. Colour white. B.B. intumesces, becomes opaque, and fuses with difficulty to a white enamel. Soluble and gelatinizes in hydrochloric acid. Chem. com. 3$\ddot{A}i\,\dot{S}i$ + 3$\dot{C}a\,\dot{S}i$ + $^{6}/_{H}$ = 38·2 silica, 31·6 alumina, 17·2 lime partly replaced by soda, and 13 water. Analyses, next page.

Fig 118.



Occurs with calcspar and other zeolitic minerals in cavities in amygdaloid, basalt, dolerite, clinkstone, and old lavas; as on Vesuvius, in Sicily, Bohemia, Tyrol, Iceland, Faroe, Scotland, and Nova Scotia. In crystallisation as well as in chemical and physical characters, Thomsonite, named after the well-known chemist, and Comptonite agree, and the *Chalilite* of Thomson is perhaps only a compact variety.

	Silica.	Alumina.	Lime.	Soda.	Magnesia.	Iron perox.	Water.	Total.	
1	38·30	30·70	13·54	4·53	...	...	13·10	100·17	Berzelius.
2	38·5	30·6	12·6	4·8	...	...	13·5	100	L. Gmelin.
3	34·63	32·35	18·65	1·25	...	...	14·00	100·88	Thomson.
4	37·08	33·02	10·75	3·70	...	...	13·00	97·55	Do.
5	36·80	31·36	15·40	...	0·20	0·60	13·00	97·36	Do.
6	37·56	31·96	15·10	...	1·08	0·72	13·20	99·62	Do.
7	39·20	30·05	10·58	8·11*a*	...	0·50	13·40	101·84	Retzius.
8	37·00	31·07	12·60	6·25	...	...	12·24	99·16	Melly.
9	38·25	32·00	11·96	6·53	...	...	11·50	100·24	Zippe.
10	38·74	30·84	13·43	3·85	0·54*b*	...	13·10	100·50	Rammelsberg.

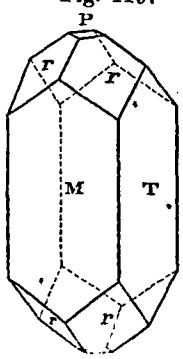
(*a*) with potash; (*b*) potash.

Nos. 1–7, Thomsonite; 8–10, Comptonite. From (1–4) Kilpatrick Hills, Dumbarton; (5, 6) Lochwinnoch, Scotland; (7) Dalsmypen, Faroe; (8) Elbogen; (9, 10) Seeberg, near Kaaden, Bohemia.

52. STILBITE, *Haüy*, *Phillips*; Desmine, *Breithaupt*, *Naumann*, *Hausmann*; Prismatoidal Kuphon-spar, *Mohs*.

Rhombic; polar edges of the pyramid P 119° 15′, and 116° according to Köhler; usual combination, $\infty\breve{P}\infty$ (*M*) . $\infty\dot{P}\infty$ (*T*) . P. (*r*) 0P . (*P*) (fig. 119), sometimes also with ∞P. The crystals broad pyramidal, very often in fascicular or diverging groups; also massive, in radiating, broad columnar aggregates; or macled. Cleavage, macrodiagonal very perfect; H. = 3·5 — 4; G. = 2·1 — 2·2. Translucent, or only on the edges; lustre vitreous, but pearly on $\infty\breve{P}\infty$. Colourless, but white, red, grey, yellow, and brown. B. B. intumesces greatly, and melts with difficulty to a white enamel. Decomposed by concentrated hydrochloric acid without gelatinizing, but leaves a slimy siliceous powder. Chem. com. $\ddot{A}l\,\ddot{S}i^3 + \dot{C}a\,\ddot{S}i^3 + 6\,\dot{H}$ = 58·2 silica, 16 alumina, 8·8 lime sometimes partly replaced by soda or potash, and 17 water. Analyses.

Fig. 119.



	Silica.	Alumina.	Lime.	Soda.	Potash.	Water.	Total.	
1	55·07	16·58	7·58	1·50 *a*	...	19·30	100·03	Fuchs and Gehlen, Iceland.
2	58·00	16·10	9·20	...	...	16·40	99·70	Hisinger, do.
3	56·08	17·22	6·95	2·17	...	18·35	100·77	Retzius, Naalsoe in Faroe.
4	57·05	16·49	7·65	1·33	0·26	17·79	100·50	Moss, Faroe.
5	60·27	14·43	6·40	0·21 *b*	...	18·50	99·71	Zellner, Nimptsch, Silesia.
6	55·75	18·50	8·05	3·0	0·01 *c*	17·00	99·31	G. Leonhard, Rienthal, Uri.
7	55·0	16·7	6·5	3·0 *d*	...	18·8	100	Delesse, Faroe.
8	58·53	15·73	7·02	3·07 *e*	0·50 *c*	17·05	101·90	Münster, Christiana.
9	58·37	16·90	6·98	1·62	0·23 *c*	14·50	98·60	Riegel, Niederkirchen.

(*a*) Alkali; (*b*) magnesia; (*c*) iron perox.; (*d*) with loss; (*e*) alkali and magnesia.

Nos. 4, 6, 9, means of two; No. 8, a bright yellow radiated variety, G. = 2·203.

Occurs in metallic veins at Andreasberg in the Hartz, Konigsberg in Norway, and Arendal; also in beds of magnetic iron ore, and in fissures or druses of granite, gneiss, and other primary strata. Most commonly in amygdaloids with other zeolites, calc-spar, and green earth. Iceland, Faroe, and the Vendayah Mountains in Hindostan, furnish the finest crystals. In Scotland, flat four-sided prisms occur in Skye, brick-red crystals at Kilpatrick, and brown at Kilmalcom. In Arran it is found in decomposed porphyry. It is rare in basalt and clinkstone.

The Sphærostilbite (No. 1 below) and Hypostilbite (No. 2) of Beudant, both from Faroe, are closely related to this species, but the former gelatinizes with acids, and the latter was probably weathered. With them the two varieties of stilbite (Nos. 3 and 4) from Dumbarton agree. Analyses.

	Silica.	Alumina.	Lime.	Soda.	Water.	Total.	
1	55·91	16·61	9·03	0·68	17·84	100·07	Beudant.
2	52·43	16·32	8·10	2·41	18·70	99·96	Do.
3	54·80	18·20	9·83	...	19·00	101·83	Thomson, white.
4	52·50	17·32	11·52	...	18·45	99·79	Do. red.

53. AEDELFORSITE, *Retzius.*

Massive, and fibrous or columnar. Cleavage, probably along a rhombic prism. H. = 6; G. = 2·6. Translucent on the edges. Colour white, light grey, and reddish. B.B. fuses with intumescence; soluble and gelatinizes in acids. Chem. com. $\ddot{A}l\,\ddot{s}i^3 + \dot{C}a\,\ddot{s}i^3 + 4\,\dot{h}$, or stilbite with two atoms less water. Analysis.

	Silica.	Alumina.	Lime.	Iron perox.	Magnesia and Mang. protox.	Water.	Total.	
1	60·28	15·42	8·18	4·16	0·42	11·07	99·53	Retzius.

Occurs at Aedelfors in Sweden. Another very distinct mineral from this locality has received the same name.

54. HEULANDITE, *Brooke, Phillips;* Stilbite, *Hauy, Hausmann, Naumann;* Hemiprismatic Kuphon-spar, *Mohs.*

Fig. 120.

Monoclinohedric; C = 63° 40′, P∞ 50° 20′, usual combination, (∞P∞) . ∞P∞ . P∞ . 0P, to which occasionally small triangular faces of the hemipyramids 2P and $\frac{2}{3}$P are associated (fig. 120). The crystals mostly tabular, more rarely prismatic in the direction of the orthodiagonal, are conjoined in druses or radiated lamellar concretions. Cleavage, clinodiagonal very perfect; brittle; H. = 3·5 — 4; G. = 2·1 — 2·2. Trans-

parent to translucent on the edges; lustre vitreous, or pearly on ($\infty P\infty$). Colourless, white, but often coloured, especially flesh or brick-red, and yellowish or hair-brown. B.B. exfoliates, intumesces, and melts to a white enamel. Soluble in hydrochloric acid, leaving slimy silica, but without gelatinizing. Chem. com. $4\,\ddot{A}i\,\dot{S}i^3 + 3\dot{C}a\,\ddot{S}i^3 + 20\,\dot{H}$, with 58·1 silica, 18·4 alumina, 7·5, lime and 16 water. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Water.	Soda.	Total.	
1	60·07	17·08	0·20	7·13	15·10	...	99·58	Walmstedt.
2	59·15	17·92	...	7·65	15·40	...	100·12	Thomson, Faroe.
3	58·2	17·6	...	7·2	16·0	...	99·0	Rammelsberg, Iceland.
4	59·64	16·33	(0·74)*a*	7·44	14·33	1·16	99.64	Damour.
5	64·2	14·1	1.2*b*	4·8	13·4	0·6	100	Delesse, Baltimore.

(*a*) potash; (*b*) iron protox. + 1·7 magnesia.

Occurs rarely in primary rocks, as in gneiss at Hadlyme, Ct., Chester, Mass., Bergen Hill in New Jersey, and other parts of N. America; in beds of ore at Arendal, and in metallic veins at Kongsberg and Andreasberg. It is more frequent in amygdaloid, or in basalt, as in Iceland, Faroe, Cape Blomidon in Nova Scotia, and the Vendayah Mountains, Hindostan. Red varieties are found in the Fassa valley, at Campsie in Stirlingshire, in Skye, and other parts of Scotland.

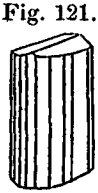
According to Breithaupt, this mineral belongs to the triclinohedric system, with which the twin crystals seem to correspond.

The *Beaumontite* of Lévy (No. 5), from near Baltimore, is said by Dana to be only Heulandite; but Lévy describes the fundamental form as a tetragonal pyramid of 147° 28′ and 46° 40′ (vide Hausmann). The crystals are very small, and of a pale or honey-yellow colour. Delesse's analysis has probably been mixed with quartz; as the solubility in acids of so siliceous a compound is very remarkable.

55. BREWSTERITE, *Brooke, Phulips, &c.*; Megallogonous Kuphonspar, *Mohs.*

Monoclinohedric; the crystals appear short prismatic, formed by several vertical prisms, and the clinopinacoids, and bounded by an extremely obtuse almost horizontal clinodoma (172°) which peculiarly characterizes them (fig. 121). They are mostly small, striated vertically, and united in druses. Cleavage, clinodiagonal very perfect; H. = 5 — 5·5; G. = 2·12 — 2·2. Transparent or translucent; lustre vitreous, on ($\infty P\infty$) pearly. Streak white. Colour white, grey, yellow, brown, or green. B.B. froths, intumesces and fuses to a porous glass. Soluble in hydrochloric acid

Fig. 121.



with separation of silica (perfectly gelatinizing, *v Kobell*). This solution yields with sulphuric acid a deposit of sulphate of barytes and strontia. Chem. com. nearly $4\,\ddot{A}i\,\ddot{S}i^3 + (2\,\dot{S}r + \dot{B}a)\,\ddot{S}i^3 + 18\,\dot{H}$, = 54·3 silica, 17·1 alumina, 8·7 strontia, 6·4 baryta with lime, and 13·5 water. Analyses.

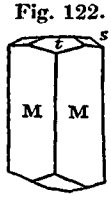
	Silica.	Alumina.	Strontia.	Baryta.	Lime.	Iron perox	Watr.	Total.	
1	53·67	17·49	8·33	6·75	1·35	0·29	12·58	100·46	Connell, Strontian.
2	53·05	16·54	9·01	6·05	0·80	...	14·73	100·18	Thomson, do.

Occurs with calc-spar in veins at Strontian, Scotland; and in amygdaloid at the Giants' Causeway. Also in the lead mines of St Turpet, near Freiburg in the Breisgau, in the Isère Dept. in France, and in the Pyrenees.

56. EPISTILBITE, *G. Rose, Phillips;* Diplogenous Kuphon-spar, *Mohs.*

Rhombic, ∞P 135° 10′, P̄∞ 109 46′, P∞ 147° 40′. These three forms usually compose the crystals (fig. 122), which are lengthened prismatically along ∞P. Macles united by a face of ∞P are more common. It also occurs massive and granular. Cleavage, brachydiagonal very perfect. H. = 3·5 — 4; G. = 2 — 2·2. Transparent or translucent on the edges. Lustre vitreous, or pearly on the cleavage planes. Colourless or white. B.B. melts with intumescence to a porous enamel, which becomes blue with cobalt solution. Soluble without gelatinizing in concentrated hydrochloric acid, but after ignition is insoluble. Chem. com. $\ddot{A}i\,Si^3 + \dot{C}a\,\ddot{S}i^3 + 5\dot{H}$, = 59 silica, 17·5 alumina, 9 lime, with soda, and 14·5 water. Analyses.

Fig. 122.



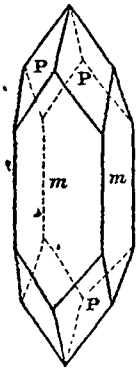
	Silica.	Alumina.	Lime.	Soda.	Water.	Total.	
1	58·59	17·52	7·56	1·78	14·48	99·93	G. Rose.
2	60.28	17·36	8·32	1·52	12·52	100	Do.

Occurs with stilbite and scolezite in Iceland and Faroe. Also, it is said, in the basalt of the Siebengebirge on the Rhine, and in Ireland. Brewster has shown that in epistilbite there is only one system of polarized rings; in heulandite two.

57. APOPHYLLITE,. *Hauy, Phillips; &c.*; Pyramidal Kuphon-spar, *Mohs.*

Tetragonal, P 121° 0′; usual forms, P, ∞P∞ (*m*) and 0P. The crystals are either pyramidal when P, or short prismatic when ∞P∞ . 0P, or tabular when 0P predominates (fig. 123). They usually form druses, and sometimes lamellar aggregates. Cleavage, basal perfect; prismatic along ∞P∞ imperfect. Brittle; H. = 4·5—5; G. = 2·3—2·4. Transparent to translucent on the edges; lustre vitreous; on 0P pearly. Colourless, but yellowish, greyish, or reddish-white, to rosé or flesh-red. In closed tube yields much water, sometimes with traces of fluorine. B.B. exfoliates, intumesces, and melts easily to a white enamel. Easily fusible in borax; with salt of phosphorus leaves a siliceous skeleton. Before ignition, small fragments exfoliate in hydrochloric acid, and the powder is readily soluble, leaving slimy silica. Chem. com. $4\,\dot{C}a^2\,\ddot{S}i^3 + \dot{K}\,\ddot{S}i^3 + 16\,\dot{H}$ with 52·8 silica, 25·4 lime, 5·3 potash, and 16·5 water; in some with a little fluorine. Analyses.

Fig. 123.



	Silica.	Lime.	Potash.	Water.	Fluorine.	Total.	
1	51·86	25·22	5·31	16·91	...	99·30	Stromeyer, Disco.
2	51·86	25·20	5·14	16·04	...	98·24	Do. Fasta.
3	52·38	24·98	5·37	16·20	0·64*a*	99·57	Berzelius, Faroe.
4	52·13	24·71	5·27	16·20	0·82*a*	99·13	Do. Utön.
5	52·03	24·43	5·27	16·20	1·54	99 57	Do. by Rammelsberg.
6	51·83	25·86	4·90	...	1·28	...	Rammelsberg, Andreasberg.
7	50 20	24·52	...	...	1·09	...	Do. Do.
8	52·44	24·61	4·75	16·73	1·43*b*	99·96	Do. Radauthal, Harz.

(*a*) Fluoric acid; (*b*) fluosilicate = 0·46 fluorine.

The amount of fluorine seems very variable, Rammelsberg having found it = 0·24 and 0·74 per cent., in two other trials on the mineral from Utoe. It is obtained as a fluosilicate, but R. considers this as a product of the analysis, and does not think that any fluoride (*Fluorür*) is here united in determinate proportions with a silicate. His "hypothesis" is, that apophyllite is a double silicate of lime and potash, in which the fluorine replaces a portion of the equally electronegative oxygen; or that part of $\dot{C}a\,\ddot{S}i$ is replaced by $(Ca\,Fl + Si\,Fl^3)$ and in like manner, part of $\dot{K}\,\ddot{S}i$, by $(K\,Fl + Si\,Fl^3)$.

Occurs chiefly in amygdaloid and other trap rocks, but also in beds of ore, or veins in primary and transition formations. Fine varieties are found at Utoe in Sweden, Aussig and other parts of Bohemia, the Seisser Alpe in Tyrol, St Andreasberg in the Hartz (red, and rarely asparagus-green, crystals at a great depth in the Samson's mine); also at Nertschinsk in Siberia, in Greenland,

Iceland, and Faroe. In Scotland, it occurs near Raith in Fife, in the cavities of fossil-shells in limestone. This species has been named *Ichthyophthalm* or fish-eye, from its characteristic pearly lustre. The *Albin* of Werner is a white opaque variety, from the Bohemian Mittelgebirge. Sir D. Brewster found, in some specimens from Naalsoe in Faroe (No. 3.), a peculiar tessellated or mosaic-like structure, and distinguished them as *Tesselite*. The *Oxhaverite* of Brewster, from Iceland, seems only a mixture with hydrate of iron and alumina.

58. OKENITE, *v. Kobell;* Dysclasite, *Connel.*

Rhombic; ∞P 122° 19′; according to Breithaupt, the combination ∞P . ∞P∞ . 0P; but usually massive, with a fine columnar or fibrous texture. H. = 5; G. = 2·28 — 2·36. Transparent to translucent on the edges. Slightly pearly. Colour yellowish to bluish-white. B.B. froths up and melts to an enamel. In powder easily soluble in hydrochloric acid, leaving gelatinous flakes; after ignition is insoluble. Chem. com. $\dot{C}a\,\dot{S}i^2 + 2\,\dot{H}$ = 57 silica, 26 lime, and 17 water. Analyses.

	Silica.	Lime.	Potash.	Soda.	Alumina.	Iron perox.	Mangan. perox.	Water.	Total.	
1	55·64	26·59	trace.	...	0·53		...	17·00	99·76	v. Kobell.
2	57·69	26·83	0·23	0·44	...	0·32	0·22	14·71	100·44	Connel.
3	54·88	26·15	...	1·02	0·46	...	...	17·94	100·45	Würth.

Occurs in amygdaloid on Disco island (No. 1), and at Tupaursak in Greenland. Also in Faroe (No. 2), and Iceland (No. 3).

59. PECTOLITE, *v. Kobell.*

Monoclinohedric? but only in spheroidal, radiating columnar masses. Cleavage, prismatic along a slightly obtuse prism. H. = 5; G. = 2·69—2·74. Translucent on the edges. Lustre slightly pearly. Colour, greyish-white or yellowish. B.B. melts easily to a clear (or white enamel-like, v. Kobell) glass. Soluble in hydrochloric acid, leaving flaky silica; after ignition gelatinizes perfectly. Chem. com. $8\,\dot{C}a\,\dot{S}i + \dot{N}a^2\,\dot{S}i^3 + 3\,\dot{H}$ = 52·1 silica, 34·2 lime, 9·5 soda with potash, and 4·2 water. Analyses.

	Silica.	Lime.	Potash.	Soda.	Alumina.	Magnesia.	Water.	Total.	
1	51·30	33·77	1·57	8·26	0·90 *a*	...	3·89	99·69	v. Kobell.
2	54·60	33·65	...	...	0·50 *a*	6·80	3·20 *b*	98·75	Beck.
3	55·96	35·12	0·60	6·75	0·08 *c*	...	0·16	99·31	Hayes.

(*a*) With iron perox.; (*b*) with carbonic acid; (*c*) with magnesia + 0·64 mangan. protox.

Occurs at Monte Baldo in the Veronese (No. 1) in amygdaloid, and at Mount Monzoni in Tyrol. In that from the latter place Berzelius found a strong reaction of fluoric acid, and hence thinks the alumina in anal. No. 1 to be fluoride of calcium. Frankenheim conjoins it with hornblende, but this is opposed by its action with acids. The *Stellite*, from Bergenhill, N. J., is, according to Dana, similar in external characters, but its composition is doubtful (anal. Nos. 2 and 3).

The *Danburite* of Shepard, from Danbury, Connecticut, transparent, vitreous, and honey-yellow, with H. = 7·5, and G. = 2·83, should come here if a pure mineral. Shepard's analysis gave 56·00 silica, 28·33 lime, 1·70 alumina, 0·85 yttria? 5·12 potash (with soda?) and loss, and 8·00 water; but Dana says it is a mechanical mixture of grains of quartz with a silicate of lime.

60. CHABASITE, *Bosc d'Antic, Jameson;* Chabasie, *Haüy, Phillips;* LEVYNE, *Brewster;* GMELINITE, *Brewster.*

Rhombohedric; R 94° 46′; the fundamental form appears generally alone, but also with $-\frac{1}{2}$R, —2R, and other subordinate forms. Intersecting macles are very common, with the twin axis the chief axis. The crystals generally collected in druses and striated Cleavage, rhombohedric along R more or less perfect. H. = 4 — 4·5; G. = 2 — 2·2. Transparent to translucent. Lustre vitreous. Colourless, but greyish, yellowish, reddish to flesh-red. Streak white. B.B. fuses to a finely porous enamel. Soluble in hydrochloric acid, some (chabasite) leaving slimy silica; others (gmelinite) gelatinizing.

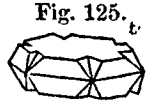
Some authors separate the Gmelinite and Levyne on account of their crystallization, which is thus given by Naumann.

Gmelinite or the Natron chabasite, R 86° 38′ (96° 18′, Breit.), $\frac{3}{2}$P2 with polar edges 141° 4′, middle edges 83° 36′: the most usual form is $\frac{3}{2}$P2 . 0R . ∞P2 (a twinform of $\frac{3}{2}$R, Breit.). The faces of the pyramid are striated parallel to their polar edges; those of the prism horizontally (fig. 124).

Levyne, R 79° 29′, the usual form being 0R . R . $-\frac{1}{2}$R, in thick tabular forms and perfect intersecting twins (fig. 125). In Phacolite, a variety of the last, R 94° 0′, the usual form $\frac{3}{2}$P2 . ∞P2 . R . $-\frac{1}{2}$R, mostly in twins. All these forms may, however, as Tamnau and others have shown, be derived from the primary form of chabasite. Analyses, next page.

Fig. 124.

Fig. 125.



Notwithstanding all these analyses, the composition of this mineral is still problematical. In most species, the oxygen of the

	Silica.	Alumina.	Lime.	Soda.	Potash.	Iron perox.	Watr.	Total.	
1	50·65	17·90	9·37	...	1·70	...	19·90	99·52	Berzelius, Gustavsberg.
2	48·38	19·28	8·70	...	2·50	...	21·14	100·00	Arfvedson, Faroe.
3	49 63	19·52	10·22	0·56	0·28	...	20·70	99·91	Hoffmann, Fassa valley.
4	48·18	19·27	9·65	1·54	0.21	...	21·10	99 95	Do. Do.
5	51·46	17·65	8·91	1·09	0·17	0·85	19·66	99·79	Do. Parsborough, N. S.
6	48·36	18·62	9·73	0·23	2·56	...	20·47	100	Rammelsberg, Aussig.
7	48·76	17·44	10·47	...	1·55	...	21·72	99·94	Thomson, Kilmalcolm.
8	50·14	17·48	8·47	...	2·58	...	20·83	99·50	Connel, Do.
9	49·20	17·91	9·64	...	1·92	...	20·41	99·08	Thomson, Do.
10	55·99	17·60	7·21	0·03	0·90	...	17·65	100·00	Rammelsberg, Parsbor.,N.S.
11	48·00	20·00	8·35	2·86	0·41	....*a*	19·30	99·32	Berzelius, Faroe.
12	46·30	22·47	9·72	1·55	1·26	(0·96*b*	19·51	102·07	Connel, Skye.
13	45·63	19·48	13·30	1·68	1·31	0·43	17·98*c*	99·95	Anderson, Leipa.
				1·77					
14	46·20	22·30	10·34			...	19·05*d*	100·00	Rammelsberg, Do.
15	46·46	21·45	10·45	0·95	1·29	...	19·40	100·00	Do. Do.
16	48·56	18·05	6·13	3·85	0·39	0·11	21·66	98·75	Connel, Glenarm.
17	46·40	21·09	3·67	7·30	1·60	...	20·41	100·47	Rammelsberg, Do.
18	46·56	20·19	3·90	7·09	1·87	...	20·41	100·02	Do. Do.
19	48·99	19·77	4·07	6·07	...	0·40	20·70	100	Thomson, Portrush.
20	47.75	20·85	5·74	2·34	1·65	...	21·30	99·63	Durocher, Faroe.

(*a*) + 0·40 magnesia; (*b*) with manganese peroxide; (*c*) + 0·14 magnesia; (*d*) + 0·34 magnesia.

alkaline bases (lime, soda, and potash) is to that of the alumina, the water, and the silica, as 1 : 3 : 6 : 8, whence Berzelius proposed the general formula $(\dot{C}a^3, \dot{N}a^3, \dot{K}^3)\ddot{S}i^2 + 3\,\ddot{A}i\,\ddot{S}i^2 + 18\,\dot{H}$, (or $\dot{R}\,\ddot{S}i + \ddot{A}i\,\ddot{S}i^3 + 6\,\dot{H}$), the lime and natron chabasites differing only in the proportion of these bases. Some (Nos. 1, 5, 11 above) contain more silica (as 1 : 3 : 6 : 9), and Rammelsberg proposes the inquiry whether the mineral may not contain quartz. In others again, the proportion of alumina is greater, and of silica less (Nos. 12, 13, 14, 15,), and these Connel and Naumann separate as Levyne and Phacolite with the formula $2\,\ddot{A}i\,\ddot{S}i^2 + \dot{C}a^2\,\ddot{S}i^3 + 10\,\dot{H} = 47{\cdot}5$ silica, 22·0 alumina, 10·8 lime (with soda and potash), and 19·7 water. No. 20, if correct, gives a still different atomic proportion. In connection with this diversity of chemical composition, it is remarkable that Sir D Brewster finds that different parts even of the same crystal of chabasite have distinct optical properties.

Occurs chiefly in amygdaloid and other trap rocks; also in lava, and more rarely in syenite, diorite, and the crystalline schists in metalliferous beds or veins. The *Chabasite* (Nos. 1–10) occurs in large beautiful crystals in Faroe, Iceland, Greenland, and Aussig in Bohemia. Smaller crystals at the Giants' Causeway, Kilmalcolm in Renfrewshire, in Skye, and other places in Scotland. The *Levyne* (Nos. 11, 12) in Faroe, Skye, Glenarm in Antrim, and Hartfield Moss in Renfrewshire. The Phacolite (Nos. 13, 14, 15) at Leipa in Bohemia. The *Gmelinite* (Nos. 16, 17, 18, 19) at Glenarm, and as the so-called Sarcolite at Montecchio Maggiore, and Castel in the Vicentine.

The *Lederite* of Jackson (No. 1 below) from Cape Blomidon, Nova Scotia, in splendent, colourless, and transparent hexagonal prisms, is probably a lime chabasite, the phosphoric acid arising, as Berzelius thinks, from a mixture of apatite. The *Acadialite*, (Nos. 2, 3, 4 below) also from Nova Scotia, of a wine-yellow or flesh-red colour, is also probably chabasite mixed like some of those above, with uncombined quartz.

	Silica.	Alumina.	Lime.	Soda.	Potash.	Iron perox	Phosphoric acid.	Watr.	Total.	
1	49·47	21·48	11·48	3·94	...	0·14	3·48	8·58	98·57	Hayes.
2	52·4	12·4	11·6	...	..	2·4	...	21·6	100·4	Thomson.
3	52 02	17 88	4·24	4·07	3·03	...	...	18·30	99·60	Hayes.
4	52·20	18·27	6·58	2·12		...	...	20·52	99·69	Do.

61. FAUJASITE, *Damour*.

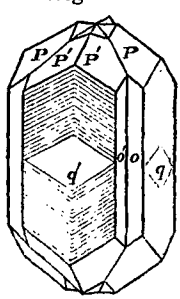
Tetragonal, P 105° 30′, primary form alone known. Fracture uneven; brittle. Scratches glass; G. = 1·923. Transparent. Lustre vitreous or adamantine. Colour white or brown. In closed tube yields much water. B.B. intumesces and fuses to a white enamel. Soluble in hydrochloric acid. Chem. com. $\ddot{A}l\ddot{s}i^3 + \dot{R}\ddot{s}i^2 + \dot{H}$, where $\dot{R}$ is lime and soda. Analysis.

	Silica.	Alumina.	Lime.	Soda.	Water.	Total.	
1	49·36	16·77	5·00	4·34	22·49	97·96	Damour.

Occurs in an augitic amygdaloid on the Kaiserstuhl in the Breisgau in Baden.

62. HARMOTOME, *Hauy, Phillips;* Cross-stone, *Jameson;* Baryte-harmotome, *Naumann;* Paratomous Kuphon-spar, *Mohs.*

Fig. 126.



Rhombic; the polar edges of the pyramid P according to Kohler, 120° 1′, and 121° 27′, those of the brachydome $\breve{P}\infty$ 111° 15′; and hence ∞P 88° 44′. Usual combination $\infty\breve{P}\infty$ (*q*) . $\infty\bar{P}\infty$ (*o*) . P . $\breve{P}\infty$, or short prismatic. Generally in perfectly intersecting macles, the chief axes coinciding, and the macrodiagonal of the one corresponding to the brachydiagonal of the other (fig. 126). Cleavage, brachydiagonal imperfect but distinct; macrodiagonal less distinct. Brittle; fracture uneven. H. = 4·5; G. = 2·3 — 2·43. Translucent;

lustre vitreous. Colourless, but white, or rarely grey, yellow, brown, or red. In closed tube yields water. B.B. fuses rather difficultly but quietly to a clear glass. Soluble but not readily in hydrochloric acid, with deposition of silica. Chem. com. $4\,\ddot{A}\dot{i}\,\ddot{S}i^3 + 3\,\dot{B}a\,\ddot{S}i^2 + 18\,\dot{H} = 48{\cdot}3$ silica, 17·8 alumina, 19·9 baryta with lime and potash, and 14 water. Analyses.

	Silica.	Alumina.	Baryta.	Lime.	Potash.	Water.	Total.	
1	49	16	18	...	...	15	98	Klaproth, Andreasberg.
2	44·79	19·28	17·59	1·09	...*a*	15·32	98·91	Wernekinck, Schiffenb. Giess.
3	46·63	16·82	20·32	0·26	1·03	15·03	100·09	Köhler, Andreasberg.
4	45·50	16·42	20·09	1·80	1·12	15·00	99·93	Do. Do.
5	48·74	17·65	19·22	...	...	14·66	100·27	Rammelsberg, Do.
6	48·68	16·83	20·09	...	...	14·68	100·28	Do. Do.
7	46·65	16·54	19·12	1·10	1·10	15·25	99·76	Köhler, Oberstein.
8	46·10	16·41	20·81	0·63	0·90	15·11	99·96	Do. Strontian.
9	48·74	15·10	14·28	3·18	2·55	14·00	97·85	Thomson, Do.
10	47·04	15·24	20·85	0·10	0·88*b*	14·92	100·11	Connel, Do.

(*a*) + 0·85 peroxide of iron and manganese; (*b*) + 0·84 soda, and 0·24 iron perox.

Fine crystals are rare, and hence the system to which this mineral belongs uncertain. The above is the common view, but some make it tetragonal others, from certain macles tesseral with the axes become unequal, and Breithaupt even triclinohedric.

Occurs in metaliferous veins in crystalline or transition rocks, where ores of silver, arsenic, lead, and zinc, with calc-spar, quartz, &c. are associated with zeolites; as at Andreasberg, Konigsberg, and in large, pure white crystals at Strontian in Argyleshire, Scotland. In amygdaloid at Oberstein, in Dumbartonshire, and other localities.

Morvenite of Thomson; small transparent crystals found with the harmotome at Strontian, agrees in angular measurement with it, but differs in composition. Analysis.

	Silica.	Alumina.	Lime.	Iron protox.	Water.	Total.	
1	64·75	13·43	4·16	2·60	14·47	99·41	Thomson.

63. PHILLIPSITE, *Lévy, Phillips;* Lime or Potash Harmotome; Staurotype Kuphone-spar, *Mohs.*

Agrees in crystalline form and other physical characters with Harmatome. G. = 2·15 — 2.19. B.B. fuses easily with slight intumescence; gelatinizes with hydrochloric acid. Chem. com. $4\,\ddot{A}\dot{i}\,\ddot{S}i^3 + 3\,\dot{R}\,\ddot{S}i + 18\,\dot{H}$; where $3\dot{R}$ is $= 2\dot{C}a + \dot{K}$ nearly. Analyses, next page.

	Silica.	Alumina.	Lime.	Potash.	Iron perox.	Water.	Total.	
1	48·36	20·00	5·91	6·41	0·41 *a*	17·09	98·64	Wernekinck, Annerode, Giessen.
2	48·51	21·76	6·26	6·33	0·99	17·23	100·38	L. Gmelin, Stempel, Marburg.
3	48·02	22·61	6·56	7·50	0·18	16·75	100·16	Do. Do.
4	50·45	21·78	6·50	3·95	...	16·82	99·50	Köhler, Stempel.
5	48·22	23·33	7·22	3·89	...	17·56	100·22	Do. Habichtswalde, Cassel.
6	47·35	21·80	4·85	5·55	3·70 *b*	16·96	100·21	Connel, Giant's Causeway.
7	43·64	24·39	6·92	10·35	...	15·05	100·35	Marignac, Vesuvius.
8	47·39	20·90	0·38	4·39	8·33 *b*	17·84	99·23	Damour, Aci reale.
9	47·46	20·18	0·25	4·17	9·35 *b*	17·65	99·06	Do. Do.

(*a*) + 0·46 baryta; (*b*) soda.

Occurs in amygdaloid, basalt, and clinkstone, as above, and also in Silesia, Bohemia, and the island Magee in Antrim. The soda was probably overlooked in the analyses before Connel's; but the amount of the constituents, and the atomic proportion of the silica and bases is very variable, so that it is uncertain how far the above form one species. Connel's analysis, No. 6, agrees with Damour's, Nos. 8, 9, of the *Herschelite* of Lévy from Aci reale in Sicily, except that in the latter the lime is nearly all replaced by soda. The Herschelite occurs in small crystals, apparently regular hexagonal pyramids with polar edges 124° 45′, and the basal pinakoid 0P. The cleavage parallel to the latter perfect. It is translucent, pearly, and of a white colour. B.B. fuses readily to a white enamel. No. 7, again, is not unlike v. Kobell's analysis of the zeagonite. It had G. = 2·213, and B.B. became white, exfoliated without intumescing, and fused to a clear glass.

64. ZEAGONITE, *Gismondi*, *Mohs*; Gismondine, *Beudant*, *Phillips*; Abrazite, *Breislak*.

There are probably two or more minerals described under this name. Hausmann gives this description of a fine specimen in his possession:—Crystallization unknown; cleavage, traces. Fracture imperfect conchoidal. Vitreous; semitransparent or translucent. Greyish-white, milk-white, or rose-red. H. = 4·5. B.B. first intumesces, loses transparency and lustre, and becomes friable; by continued blowing phosphoresces strongly and melts rather easily to a white enamel. Gelatinizes with muriatic acid.

Naumann again describes it as:—Tetragonal, P 85° 2′, usual combination ∞P∞ . P, the crystals chiefly in spheres or bundles. Cleavage, prismatic imperfect. H. = 6 — 6·5; G. = 2·18. Bluish-white or grey, smalt-blue or reddish-grey; splendent; transparent to translucent. B.B. infusible. Analyses, next page.

	Silica.	Alumina.	Lime.	Potash.	Magnesia.	Iron perox.	Mang. perox.	Water.	Total.	
1	42·60	25·50	7·50	6·90*a*	...	...	...	17·66	100·06	v. Kobell, Capo di Bove.
2	42.84	26·04	7·70	5·76*a*	...	...	...	17 66	100·6	Do. Do.
3	41·4	2·5	49·6	...	1·5	2·5	...	...	96·5	Carpi, Do.
4	57·45	7·36	25·30	...	2·56	3·00	0·50	...	96·17	Viviani.
5	35·88	27·23	13·12	2·85*b*	...	...	...	21·10	100·18	Marignac, Vesuvius.

(*a*) With traces of soda; (*b*) potash.

These analyses cannot be reconciled with each other, and are probably of distinct minerals. No. 5 had G. = 2·265; at 100° cent. lost a third of its contents in water and became opaque, thus differing from Phillipsite. In composition it approaches prehnite. Berzelius conjectures that Nos. 1 and 2 were mixed with Phillipsite. Some small pale blue transparent crystals from Vesuvius in tetragonal octahedrons with lateral edges = 122° 58′ Phillips, and H. = 7 — 7·5 are, Hausmann thinks, undoubtedly zircon.

65. LAUMONITE, *Hauy, Phillips;* Diatomous kouphone-spar, *Mohs.* Monoclinohedric, ∞P 86° 15′, ∞P : 0P 104° 20′; the crystals, chiefly of the combination ∞P . 0P, are prismatic and united in druses; also massive, in long distinct grains. Cleavage, orthodiagonal perfect; clinodiagonal in traces; rather brittle. H. = 3 — 3·5 (when fresh, = 5 — 6 ?); G. 2·2 — 2·3. Transparent to translucent on the edges. Lustre vitreous, on the cleavage planes pearly. White, greyish, yellowish, reddish, sometimes flesh-red. When exposed to the air, it soon loses its lustre and transparency, and is decomposed. B.B. intumesces and melts easily to a white enamel, which becomes clear in a stronger heat. Soluble and gelatinizes in hydrochloric acid. Chem. com. $\ddot{A}i\ \dot{S}i^3 + \dot{C}a\ \dot{S}i + 4\dot{H} = 51{\cdot}8$ silica, 21·5 alumina, 11·3 lime, and 15·4 water. Analyses.

	Silica.	Alumina.	Lime.	Water.	Total.	
1	48·3	22·7	12·1	16·0	99·1	L. Gmelin, Huelgoët.
2	51·98	21·12	11·71	15·05	99·86	Dufrénoy, Phipsburg, Maine, N.A.
3	50·38	21·43	11·14	16·15	99·10	Do. Courmayeur, Savoy.
4	52·04	21·14	10·62	14·92	98·72	Connel, Snizort, Skye.
5	51·17	21·23	12·43	15·17	100	Delffs.
6	52·3	22·3	12·0	14·2	100·8	V. Babo.

Occurs rarely in veins or druses in the crystalline and trap-rocks. It also forms a constituent of some greenstones, as at Kuchelbad, near Prague, and in other parts of Bohemia, then hastening their decomposition. It is very generally associated with calc-spar. Discovered at Huelgoët, in Brittany, by Gillet Laumont. Very fine varieties are found in clay-slate at Eule in Bohemia, and at Lischnitz in greenstone; also in Tyrol, the Ural, Kongsberg, Fahlun, Ice-

land, Faroe, and in Skye, Dumbarton, and other parts of Scotland; and in several places in North America.

66. LEONHARDITE, *Blum.*

Monoclinohedric; ∞P 83° 30′, ∞P : 0P 114°. The crystals of the combination ∞P. 0P are prismatic, and either irregularly aggregated, or grouped in bundles. Also massive with a granular or columnar texture. Cleavage, prismatic along ∞P very perfect; basal imperfect. Very friable. H. = 3 — 3·5; G. = 2·25. Translucent on the edges, but opaque when weathered. Lustre pearly. Yellowish-white. B.B. exfoliates, froths, and melts easily to a white enamel. In closed tube yields much water. Decomposes quickly in the air. Soluble in acids. Chem. com. $\dot{Ca}^3\,\ddot{Si}^4 + 4\,\ddot{Al}\,\ddot{Si}^3 + 12\,\dot{H} = 55{\cdot}5$ silica, 23 alumina, 9·4 lime, and 12·1 water. Analyses.

	Silica.	Alumina.	Lime.	Water.	Total.	
1	56·13	22·98	9·25	11·64	100	Delffs, Schemnitz.
2	54·92	22·49	9·05	13·54	100·00	Ib. by Rammelsberg.
3	55·00	24·36	10·50	12·30	102·16	Von Babo, Schemnitz.

Found in clefts and druses in a trachytic rock at Schemnitz, Hungary, and formerly considered Laumonite, which it much resembles. In No. 1, the mineral was dried at 100°, and No. 2 is the same analysis with the water as when only dried in the air.

67. GLOTTALITE, *Thomson.*

Tesseral, O and $\infty O\infty$, crystals grouped in druses; cleavage unknown. H. = 3 — 4; G. = 2·18. Highly translucent, vitreous. Colourless or white. In closed tube yields water. B.B. melts with intumescence to a white enamel. Chem. com. $3\,\dot{Ca}\,\ddot{Si} + \ddot{Al}\,\ddot{Si} + 8\dot{H}$. Analysis.

	Silica.	Alumina.	Lime.	Iron perox.	Water.	Total	
1	37·01	16·31	23·93	0·50	21·25	99·00	Thomson.

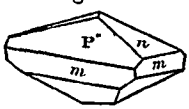
Occurs in greenstone probably near Port-Glasgow, on the Clyde (Glotta).

68. EDINGTONITE, *Haidinger;* Pyramidal Brythyne-spar, *Mohs.*

Tetragonal; sphenoidal-hemihedric; P 87° 9′, formed as a sphenoid (*P*), with polar edges 92° 51′; and $\frac{1}{2}P$ (*n*) also as a sphenoid, with polar edges 129° 8′. Usually these two sphenoids, in reversed position,

are combined with ∞P (*m*), giving the small crystal, fig. 127, a pyramidal aspect. Cleavage prismatic along ∞P perfect. H. = 4—4·5; G. = 2.7—2·75. Semi-transparent or translucent. Lustre vitreous, but faces of ½P dull. Greyish-white. In closed tube yields water. B.B. fuses rather difficultly to a colourless glass. Chem. com. unknown. Analysis.

Fig. 127.



	Silica.	Alumina.	Lime.	Water.	Total.	
1	35·09	27·69	12·68	13·32	88·78	Turner.

The quantity analysed was very small, and the loss probably soda or potash. Found with Thomsonite in the Kilpatrick Hills, Dumbartonshire, but very rare.

VII. Family.—Mica.

69. Potash-mica, Glimmer, *Werner* (in part); Mica, *Hauy*, *Phillips*, *&c.* (in part); Hemiprismatic Talc-mica, *Mohs*, (in part).

Monoclinohedric, but dimensions not accurately known. Crystals chiefly rhombic or six-sided tables (seldom prisms), with the side edges inclined to each other at 120° 46′ and 59° 14′, and to the terminal plane at 98° 40′ and 81° 20′ (G. Rose). The crystals are imbedded, or attached in druses; also massive and disseminated, or form scaly, foliated, or lamellar aggregates. Macles rather rare. Cleavage, basal highly perfect; sectile, and in thin lamellæ, elastic. H. = 2 — 3; G. = 2·8 — 3·1. Pellucid in various degrees; transparent laminæ optically binaxial. Lustre metallic-pearly, on some faces vitreous. Colourless, but coloured white, grey, green, red, brown, black, and rarely yellow. Often different tints in transmitted and reflected light. In closed tube usually yields water, with traces of fluorine. B.B. loses its transparency, and fuses more or less readily to an obscure glass or white enamel. Not affected by hydrochloric or sulphuric acids. In borax melts to a glass generally coloured by iron. Chem. com. very variable, but, according to L. Gmelin, on the whole nearly 3 $\ddot{A}\ddot{i}\ \ddot{S}i + \dot{K}\ \ddot{S}i^3 = 48$ silica, 39·8 alumina, and 12·2 potash; part of the potash occasionally replaced by protoxide of iron or manganese, and of the alumina by the peroxide of these metals, or of chrome. Analyses, next page.

	Silica.	Alumina.	Iron perox	Man. perox.	Magnesia.	Pot.	Soda.	Lime.	Flu. acid.	Watr.	Total.	
1	48·00	34·25	4·50	0·50	...	8·75	...	...	...	1·25 *h*	97·25	Klaproth.
2	47.50	37·20	3·20	0·90	...	9·60	...	...	5·56	2·63	101·59	H. Rose.
3	46 10	31·60	8·65	1·40	...	8·39	...	...	1·12	1·09	98·26	Do.
4	46.22	34·52	6·04	2·11 *a*	...	8·22	...	...	1·09	0·98 *b*	98·18	Do.
5	46·36	36·80	4·53	0·002*a*	...	9·22	...	...	0·77	1·84	99·52	Do.
6	47·19	33·80	4·47	2·58 *a*	...	8·35	...	0·13	0·29	4·07	100·88	Do.
7	36·54	25·47	27·06	1·92	...	5·48	...	0·93	2·70	...	100·10	Turner.
8	47·97	31·69*d*	5·37	1·67	...	8·31	...	...	0·72 *g*	3·32	99·40	Svanberg.
9	39·45	9·27	35·78	2·54	3·29	5·06	0.32 *e*	0·31	0·29 *g*	1·83	99·567	Do.
10	41·30	15·35	1·77	...	28 79	9·70	0·65 *f*	...	3·30 *g*	0·28 *h*	101·14	Meitzendorff
11	40·91	17·79	11·02	...	19·04	9·96	...	0·30	...	...	99·0 ?	Chodnew.
12	39·85	16·07	13·21	...	15·60	13·68*k*	...	0·12	...	...	100·00	Varrentrapp
13	47·95	34·45	1·80	...	0·72	10·75	0·37	0·42 *l*	0·35 *g*	...	100·76	Schaffhäutl.
14	47·68	15·15	5·72	1·17	11·58	7·27	1·17	... *i*	trace *g*	2·86	93·51	Do.
15	50 20	35·90	2·36	...	...	...	8·45	...	...	2 45	99·36	Do.
16	47·31	5·74	28·91	0·48	10.17	1·05	...	6·23	...	...	99·89	Mitscherlich.

(*a*) With magnesia; (*b*) trace of titanic acid; (*c*) protoxide; (*d*) + 0·35 aluminium; (*e*) calcium + 1·45 iron protoxide; (*f*) with a little lithia; (*g*) fluorine; (*h*) loss by heat; (*i*) + 5·91 chrome-oxide; (*k*) with soda and loss; (*l*) calcium, + 3·95 chrome-oxide.

From (1) Siberia (silver-white); (2) Utne; (3) Broddbo, near Fahlun; (4) Fahlun; (5) Kimito in Finnland; (6) Ochotzk; (7) Cornwall, brown; (8) Broddbo; (9) Aborforss in Finnland; (10) Jefferson County, New York, brown; B.B. melts easily to a white enamel, colouring the flame pale-red; (11) Vesuvius, blackish-green, part of the iron evidently protoxide; (12) Zillerthal; (13) Fuchsite, from Schwarzenstein in Zillerthal, emerald or dark-green colour; (14) chrome mica, found with Nos. 1, 3; B.B. only fusible in very thin leaves; almost wholly soluble in hydrochloric acid; (15) St Gotthardt.

These analyses show the very varied composition of this mineral. The fluorine found in many is often thought accidental, but H. Rose finds it most abundant in the best characterized varieties,—as those from granite. He has found it in grey mica from Broddbo, Zinnwald, Altenberg, Murzinsk, Siberia; in gold-yellow mica from Kimito, Borstils Sacken in Sweden, Utoe; and in other specimens from Massachusetts, Russia, Pargas, and Sala. Those in which it is most abundant (the first 7 or 8) lose their colour and lustre on ignition; the poorer varieties more or less retain them. He also shows that the fluorine increases or decreases with the proportion of iron.

The variety (No 10 anal.) was determined to be diaxial by Dove, but contains a proportion of magnesia, formerly thought peculiar to the monoaxial micas. No. 11 was found by G. Rose to have a monoclinohedric crystallization, and therefore should be optically diaxial, though this could not be ascertained; whereas, in composition it resembles the monoaxial. No. 12 was likewise monoclinohedric, and No. 14 diaxial. Poggendorf also states that the magnesian-mica from lake Baikal (No. 1 below) was diaxial, and thus also anomalous. Hence the connection between the crystallographic, optical, and chemical characters of mica seems still uncertain.

Mica is a very common mineral, and forms a considerable portion of the earth's crust. It enters as a primary constituent into granite,

gneiss, mica-slate, and other crystalline rocks. Accidentally it is found in syenite, euphotide, hypersthene-rock, diorite, many porphyries, trachyte, and basalt. It also forms part of the sedimentary rocks produced from the destruction of these. More rarely it occurs in lava, or volcanic ejectamenta, in granular limestone, dolomite, magnetic iron-ore, iron-glance, iron-pyrites, copper-pyrites, and other ores. It usually appears in crystalline scales or leaves, lying parallel to the laminæ of the slaty rocks; but rarely, as in some chlorite slates, at right angles to the lamination. The largest mica plates occur in granite veins,—as at Skutterud in Norway, Finbo in Sweden, in Brazil, and especially in Siberia, where the plates, often a yard in diameter, and named Muscovy glass, are used for windows, but become white on exposure. Fine crystals are found at Vesuvius, the Ilmen mountains, St Gotthardt, Pargas, Arendal, and in Cornwall and Aberdeenshire. Spherically curved plates occur at Kimito in Finuland. According to Hauy, mica will divide into laminæ one 250,000th of an inch thick, and it is thus well adapted for various optical purposes. Mica shows a great tendency to associate with quartz, and, in a less degree, with the felspathous minerals. It likewise often occurs intimately united with andalusite, pinite, and tourmaline. It seems sometimes to form whole rocks, and some so-called talc slates, as that of St Gotthardt, in which the cyanite is found (*Paragonite* of Schaffhäutl), seem merely this mineral, anal. No. 15.

Mica is occasionally formed during metallurgic processes; No. 16 being such an artificial mica from the copper furnaces of Garpenberg in Sweden. The sandstone forming the walls of iron furnaces is also often changed into a foliated pearly mineral very like mica, probably from the influence of the wood ashes.

70. LITHIA-MICA; LEPIDOLITE, *Werner*, *&c.* Synonyms as in last species.

Monoclinohedric (or triclinohedric?), but dimensions unknown. In crystallization and physical characters agrees with potash-mica, but colour often rose or peach-blossom red. In the closed tube shows evident fluorine reaction. B.B. melts *very easily* with effervescence to a colourless, brown, or rarely black magnetic glass, colouring the flame *red* (especially with fluor-spar or sulphate of potash). Imperfectly soluble in acids, wholly so after fusion. Chem. com., according to L. Gmelin, generally 3 $\ddot{A}\dot{l}\,\ddot{S}i^2 + 2\,\dot{L}i\,\ddot{S}i + (KF, SiF^2)$, with 51·6 silica, 28·5 alumina, 8·7 potash, 5·3 lithia, and 5·9 fluoric acid; but many contain much protoxide of iron and manganese, and some correspond better with $4\,\ddot{A}\dot{l}\,\ddot{S}i^3 + KF^2 + 2\,Li\,F$; others with $\ddot{A}\dot{l}\,\ddot{S}i^3 + RF$. Analyses, next page.

	Silica.	Alumina.	Mang. prot.	Iron prot.	Potash.	Lithia	Soda.	Fluor. acid.	Watr.	Total.	
1	52·25	28·35	3·66	...	6·90	4·79	...	5·07	trace	101.02	C. Gmelin.
2	49·06	33·61	1·40*a*	...	4·19	3·59	0·41*b*	3·45	4·18*c*	100	Do.
3	46·23	14·14	4·57	17·97*a*	4·90	4.21	...	8·53	0·83	101·38	Do.
4	44·28	24·53	1·66	11·33	9·47	4·09	...	5·14	...	100·50	Turner.
5	40·19	22·79	2·02	19·78	7·49	3·06	...	3·99	...	99·25	Do.
6	50·82	21·33	trace	9·08	9·86	4·05	...	4·81	...	99·95	Do.
7	40·06	22·90	1·79	27·06*a*	4·30	2·00	...	2·71	...	100·82	Do.
8	50·35	28·30	1·23	...	9·04	5·49	...	5·26	...	99·61	Do.
9	50·91	28·17	1·08	...	9·50	5·67	...	4·11	...	99·44	Do.
10	47·76	20·29	4·67	0·12*d*	10·96	2·77	2·23	10·22*e*	1·16*f*	100·18	Rosales.
11	47·01	20·35	1·53	14·34*a*	9·62	4·33	0·40*f*	1·43*e*	1·53	100·54	Stein.
12	42·97	20·59	0·63*a*	14·18*a*	10·02	1·60	1·41*g*	6·35*e*	0·22	98·38	Lohmeyer.

(*a*) Peroxide; (*b*) magnesia; (*c*) with loss + 0·112 phosphoric acid; (*d*) lime; (*e*) fluorine; (*f*) chlorine; (*g*) + 0·21 chlorine.

From—(1) Penig in Saxony; (2) Rozena in Moravia; (3, 4) Zinnwald in Bohemia; (5) Altenberg; (6) Cornwall, grey; (7) do. brown; (8) Ural; (9) Utoe; (10) Ural, mean of three (the silica probably too small, the alkalis and lithia metallic, and not the oxides); (11) Altenberg in Erzgebirge; (12) Zinnwald (same as Nos. 3, 4); B.B. melts to a black enamel.

As above stated, this mineral also varies much in composition, and the formula is still uncertain. Its chief characteristic is the large amount of fluorine, and the presence of 2 — 6 per cent. lithia. The soda shown in the more recent analyses was probably left with this in the older ones. According to Fownes and Sullivan, it contains a large amount of phosphoric acid, already noticed by C. Gmelin (No. 2). The red varieties are said to contain only the peroxide of manganese, and not that of iron. Lepidolite occurs in granite, gneiss, and veins of quartz, though far less common than the potash-mica, with which it is probably often confounded. The crystallized varieties are chiefly from veins of tin ore in Bohemia, Saxony, and Cornwall. It is sometimes used as an ornamental stone.

71. MAGNESIA-MICA; BIOTITE, *Hausmann*; Mica, *Phillips*, *Hauy*, *&c.* (in part); Rhombohedral Talc-mica, *Mohs*.

Hexagonal; P 149°, the crystals are mostly tabular from the predominance of 0P, rarely short prisms. It occurs imbedded, or attached and in druses; also massive, forming laminar, scaly, or other aggregates. Cleavage, basal very perfect. Sectile, sometimes brittle, and in thin plates elastic. H. = 2·5 — 3; G. = 2·85 — 2·9. Transparent, but often only in very thin plates, and then generally mono-axial. Lustre metallic pearly on 0P. Usually dark-green, brown, or black, rarely other colours. Streak greenish-grey or white. B.B. difficultly fusible to a grey or black glass. In closed tube often yields water, with traces of fluorine. Scarcely affected by hydrochloric acid, but completely soluble in concentrated sulphuric acid, leaving white pearly plates of silica. Chem. com. very variable, but usually given as $\ddot{R}\ddot{S}i + \dot{R}^3\ddot{S}i^2$ (the same with garnet), $\dot{R}$ being = $\dot{M}g$, $\dot{K}$, $\dot{F}e$; but L. Gmelin

shows that some agree well with $\ddot{A}\dot{i}\,\ddot{s}i + \dot{R}^4\,\ddot{S}i^3$, and others with $\ddot{A}\dot{i}\,\ddot{s}i + 2\,\dot{R}\,\ddot{s}i$. Analyses.

	Silica.	Alumina.	Iron perox.	Iron protox.	Magnesia.	Potash.	Fluoric acid.	Water.	Total.	
1	42·01	16·05	4·93	..	25·97	7·55	0·68	.... *b*	97·19	H. Rose.
2	40·00	12·67	19·03	1·63 *a*	15·70	5·61	2·10	1·07	97·37	Do.
3	42·12	12·83	10·38	9·36	16·15	8·58	....	4·30	100·49	v. Kobell.
4	41·00	16·88	4·50	5·05	18·86	8·76	trace.	3·00	99·35	Do.
5	40·00	16·16	7·50	0·20 *a*	21·54	10·83	0·53	0·75 *c*	99·76	Do.
6	39·75	15·99	8·29	....	24·49	8·78	....	3·35 *c*	99·62	Bromeis.
7	42·59	21·68	10·39	....	10·27	8·45	0·51 *d*	3·17 *f*	98·81	Sjanberg.
8	42·46	12·86	....	7·11	25·39	6·03	0·62 *d*	1·13 *g*	99·16	Do.
9	44·41	16·86	....	20·71	11·26	4·05	0·41 *d*	0·44	101·61	Do.
10	40·86	15·13	13·00	....	22·00	8·83	....		100·26	v. Kobell.

(*a*) Titanic acid; (*b*) + 0·63 peroxide of manganese; (*c*) loss by heat + 0·87 lime, and 0·10 undecomposed mineral; (*d*) fluorine; (*e*) + 0·75 protoxide of manganese, 0·26 lime, and 0·56 calcium; (*f*) + 1·06 manganese protoxide, 0·35 magnesium, and 0·10 aluminium; (*g*) + 0·46 manganese protoxide, 0·90 lime, and 0·43 calcium.

From (1) Lake Baikal; (2, 3) Miask; (4) Karosulik, Greenland; (5) Monroe, New York; (6) Vesuvius; (7) Pargas; (8) Sala; (9) Rosendahl near Stockholm; (10) Bodenmais, G. = 2·7.

These analyses seem incapable of being comprised under any common formula. The chief characteristic is the large proportion of magnesia, and the smaller of alumina. As stated above, the optical characters do not correspond with the chemical, and, were they neglected, Nos. 10, 11, 12, 14 of potash-mica should come under this species.

This mineral seems far less common than potash-mica, from which, however, it has rarely been distinguished. It seldom forms an essential constituent of mountain rocks (Miascite of Ilmen), but is more often accidentally disseminated in them (chlorite slate of Ural, &c.), or in subordinate beds and veins. Remarkable varieties are found at Monroe in North America, Karosulik in Greenland, and in the ejected blocks on Vesuvius.

The *Rubellan* of Breithaupt, brownish-red, hexagonal tables, found in Bohemia and Saxony in wacke and amygdaloid, seems this mineral.

72. LEPIDOMELANE, *Hausmann.*

Hexagonal; in small six-sided tables seldom above half a line broad, forming a granular scaly aggregate. Cleavage, basal perfect. Rather brittle. H. = 3; G. = 3·0. Lustre vitreous, inclining to adamantine; colour raven-black; streak mountain-green. Opaque, but very thin laminæ translucent, with leek-green light. B.B. becomes brown, and fuses to a black magnetic bead; in borax forms a bottle-green glass. Soluble in hydrochloric or nitric acid, leaving pearly scales of silica. Chem. com. $(\ddot{A}\dot{i}, \ddot{F}\dot{e}_2)\,\ddot{s}i + (\dot{F}e, \dot{K}_2)\,\ddot{s}i$. Analysis, next page.

	Silica.	Alum.	Iron peroxide.	Iron protoxide.	Magnesia.	Lime.	Potash.	Watr.	Total.	
1	37.40	11.60	27.66	12.43	0.60		9.20	0.60	99.49	Soltmann.

Probably from Persberg in Wermeland. The *Raben-glimmer* of Breithaupt seems the same mineral.

73. CHLORITOID, *Breithaupt;* Chlorite-spar, *Fiedler*, *Mohs.*

Massive, in coarse granular aggregates, composed of curved foliæ. Cleavage in one direction perfect. Brittle. H. = 5.5—6; G. = 3.55. Opaque or translucent in thin laminæ. Lustre weak pearly; colour blackish-green; streak greenish-white. B.B. is infusible, but becomes darker and magnetic. Not affected by acids. Chem. com. $\ddot{Al}^2\dot{S}i + \dot{Fe}^2\dot{S}i$, with 26·2 silica, 43·4 alumina, and 30·4 iron protoxide. Analyses.

	Silica.	Alumin.	Iron protox.	Mang. protox.	Magnes.	Water	Total.	
1	24·90	46·20	28·89	...	...	...	99·99	Erdmann, Ural.
2	24·96	43·83	31·21	...	...	...	100·00	Do.
3	24·40	45·17	30·29	...	...	...	99·86	Gerathewohl, Do.
4	27·48	35·57	27·05	0·30	4·29	6·95	101·64	Bonsdorff, Do.
5	24·1	43·2	23·8	...	...	7·6*a*	98·7	Delesse, St Marcel.
6	33·20	29·00	25·93	6·00	0·24	5·60	96.97	Jackson, Rhode Island.

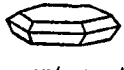
(*a*) + traces of titanic acid.

The chloritoid occurs in chlorite slate at Kosoibrod near Katharinenburg in the Ural along with diaspore. Most specimens yield water in the closed tube, and G. Rose thinks Bonsdorff's analysis (No. 4) gives the true constitution. It would then agree with the *Sismondine* of Delesse from St Marcel in Piemont (No. 5), which is similar in external characters, and only differs in containing water. Dana thinks the *Masonite* of Jackson (No. 6) from Natic village, Rhode Island, nearly allied, but the purity of the specimen analysed is doubtful. In No. 3 the mineral was digested in diluted hydrochloric acid, and then dried at 212° F.

74. CHLORITE, *Werner*, *Phillips;* Talc, *Hauy*, (in part); Ripidolite, *G. Rose*, *Rammelsberg;* Prismatic Talc-mica, *Mohs*, (in part).

Hexagonal; P 120°, v. Kobell (106° 50′ Descloizeaux). The crystals tabular of 0P . ∞P or 0P . P (fig. 128), but often united in comb-like or other groups. Generally massive, and scaly, or imbedded in other minerals. Cleavage, basal perfect; laminæ flexible, but not elastic. H. = 1 — 1·5; G. = 2·78 — 2·96. Thin plates transparent or translucent. Lustre pearly; colour, leek, celadine, pistacio or blackish-green; the crystals often red transverse to

Fig. 128.



the chief axis. Streak green or greenish-grey. In the closed tube yields water. B.B. difficultly fusible on thin edges; soluble in concentrated sulphuric acid. Chem. com. $2\dot{R}\,\dot{S}i + \dot{R}^2\,\ddot{A}l + 3\,\dot{H}$, or when $4\,\dot{R}$

$= 3\,\dot{M}g + \dot{F}e$, $= 26{\cdot}3$ sil., $21{\cdot}8$ al., $25{\cdot}5$ mag., 15.0 Fe, and $11{\cdot}5$ watr.

$= 2\,\dot{M}g + 2\dot{F}$, $= 24{\cdot}6$ ... $20{\cdot}1$ ... $15{\cdot}9$ ... $28{\cdot}5$ ... $10{\cdot}9$ ...

but the analyses are variable, and part of the iron probably the peroxide. Analyses.

	Silica.	Alumina	Magnesia.	Iron protox	Mang. Prot.	Water.	Total.	
1	26·51	21·81	22·83	15·00	...	12·00	98·15	v. Kobell, Greiner, Zillerthal.
2	27.32	20·69	24·89	15·23	0.47	12·00	100·60	Do. Schwazenstein, Do
3	26.06	18·47	14·69	26.87	0·62	10·45*a*	99·40	Do. Rauris.
4	25·37	18·50	17·09	28·79	...	8·96	98·71	Varrentrapp, St Gotthardt.
5	26·88	17·52	13·84	29·76	...	11·33	99·33	Marignac, St Christopher.
6	27·14	19·19	16·78	24·76	...	11·50	99·37	Do. Mont des Sept-Lacs
7	31·54	5·44	41.54	10·18*b*	...	9·32	98·02	Varrentrapp, Pfitsch, Tyrol.
8	30·2	13·2	37 9	3·1*b*	...	17·0	101·4	Giwartowsky.
9	25·60	22·21	30·96	5·00*b*	...	13·43*c*	99·45	Hermann.

(*a*) + 2·24 remainder; (*b*) peroxide; (*c*) + 2·25 undecomposed matter and magnetic iron. 1-4, Foliated chlorite; 5, 6, scaly from the granite of Dauphiné; 7, chlorite slate; 8, 9, steatite.

Chlorite is one of the most widely-dispersed and geologically-important minerals. Externally it resembles mica, and is frequently associated with, or replaces it, in granite, gneiss, and similar rocks. It is a component of the diabase porphyries and amygdaloids, and then often crystallized; and is occasionally found in diorite, euphotide, and serpentine; more rarely in greenstone porphyry, amygdaloid, basalt, and trachyte. It is most abundant in chlorite slate or in beds of pot-stone, intimately mixed with talc, for which it shows a strong affinity. From these it has passed into various sedimentary rocks, which owe to it their green colour. It is also common in beds or veins of ore, as of magnetic iron, in dolomite and marble, and is frequently associated with the almandine garnet, tremolite, schorl, and rutile.

The Alps, Scandinavia, the Ural, the Harz, and many parts of Scotland, are well known localities of chlorite, both in its crystallized variety and as a constituent of rocks. Chlorite slate (No. 7) differs considerably in composition from the simple mineral. Some steatites seem only decomposed chlorite, as those from Snarum (No. 8), and the greenish variety (No. 9) from near Miask.

75. RIPIDOLITE, *von Kobell, Hausmann*; Chlorite, *G. Rose, Rammelsberg.*

Rhombohedric; R : 0R = 104° 15′; crystals chiefly tabular and often in comb-like or fan-shaped groups. Cleavage, basal very perfect. Sectile and flexible, but not elastic; H. = 2 —3; G. = 2·61

— 2·77. Translucent, or in thin leaves transparent. Lustre pearly. Colour green, but red by light transmitted transverse to the axis. Streak colourless. B.B. exfoliates, becomes white, and fuses on the edges to a white enamel. Completely soluble in warm sulphuric acid. Chem. com. 3 $\dot{M}g\,\dot{S}i + \dot{M}g^2\,\ddot{A}l + 4\,\dot{H}$ = 33·2 silica, 18·3 alumina, 35·7 magnesia, and 13·8 water; or 5 $\dot{M}g\,\dot{S}i + \dot{M}g^3\,\ddot{A}l^2 + 6\,\dot{H}$ = 32·9 silica, 21·8 alumina, 33·9 magnesia, and 11·4 water. The iron is either the peroxide replacing alumina, or more probably, in part at least, the protoxide replacing magnesia, when the first formula is the more correct. Analyses.

	Silica.	Alumina.	Magnesia.	Iron protox.	Manga. protox.	Water.	Total.	
1	32·68	14·57	33·11	5·97	0·28	12·10*a*	99·73	v. Kobell, Schwarzenstein.
2	31·14	17·14	34·40	3·85	0·53	12·20*a*	100·11	Do. Achmatowsk.
3	30·38	16·97	33·97	4·37	...	12·63	98·31	Varrentrapp. Do.
4	31·47	16·67	32·56	5·97	0·01	12·43	99·11	Bruel, Zillerthal.
5	32·1	18·5	30·7	0·6	...	12·1	100	Delesse, Maulèon.
6	30·01	19·11	33·15	4·81*b*	...	12·52	99·60	Marignac, Alathal.
7	30·27	19·09	33·13	4·42*b*	...	12·54	100·25	Do. Slatoust.
8	30·80	17·27	37·08	1·37*b*	...	12·30	98·82	Hermann, Urah
9	33·45	9·50	32·67	11·33	...	12·04	98·99	Schweitzer, Zermatt, Valais.
10	33·37	13·33	34·39	5·83*b*	(0·18)*c*	12·77	99·88	Marignac, Do. Do.
11	33·95	13·46	33·71	6·12*b*	(0·24)*c*	12·52	100	Do. Binnen, Do.
12	34·23	16·31	35·36	3·33*b*	1·75*d*	8·68	99·66	Komonen, Slatoust.
13	32 35	18·00	32·29	4·37	...	12·50	99·51	Hermann, Do.

(*a*) In No. 1 + 1·02, in No. 2 + 0·85 undecomposed matter; (*b*) peroxide; (*c*) chrome oxide; (*d*) lime.

Nos. 1–8 are the ripidolite, Nos. 9, 10, 11 the pennine of Fröbel from the Valais, which agrees so closely with ripidolite as to justify Rammelsberg in combining them. It crystallizes in acute rhombohedrons (R 63° 15′) generally so much truncated by 0R as to become tabular. It is leek, bluish, or blackish-green, with a hyacinth red or brown tint across the axis, and a distinguished dichroism. In hydrochloric acid it forms a green solution, the silica separating in scales.

Ripidolite is known only from a few localities, but in many is probably confounded with chlorite, from which it has only recently been disjoined. The finest crystals occur in druses often with garnets and diopside. No. 8 above is a silver-white crystallized variety, G. = 2·603, found in fissures in chrome iron ore near the Balschoi Iremel river, near Slatoust. Besides the above places, Reichenstein in Silesia, and Arendal, furnish fine varieties.

Nos. 12, 13, the *Leuchtenbergite* of Komonen, of a yellowish-white colour, is shown by Hermann's analysis to be only ripidolite, perhaps partially decomposed.

76. TALK, *Werner, Hauy, Phillips, &c.*; Prismatic Talc-mica, *Mohs* (in part).

Rhombic or monoclinohedric. Rarely found in six-sided or rhom-

bic tables, not admitting of measurement. Generally massive in curved foliæ, or granular, scaly aggregates; also slaty or earthy. Cleavage, basal very perfect. Soft, sectile, and flexible in thin plates. H. = 1; G. = 2·68 — 2·75. Transparent in thin plates, and optically diaxial. Lustre pearly or resinous. Colourless, but generally greenish or yellowish-white, to apple, leek, or olive-green. Feels very greasy. B.B. emits a bright light, exfoliates, and hardens, but is infusible. With salt of phosphorus, yields a silica skeleton; with solution of cobalt, becomes pale red. Not soluble in hydrochloric or sulphuric acid before or after ignition. Chem. com. $\dot{Mg}^6 \ddot{Si}^7 = 64{\cdot}4$ silica, and 35·6 magnesia; or $\dot{Mg}^7 \ddot{Si}^8 = 63{\cdot}9$ silica, and 36·1 magnesia; but a part of the latter often replaced by iron-protoxide. The water in some is probably incidental. Analyses.

	Silica.	Magnesia.	Iron protox.	Alumina.	Watr.	Total.	
1	58·2	32·2	4·6	...	3·5	99·5	Berthier, St Bernhard.
2	55·6	19·7	11·7	1·7	2·6*a*	99·4	Do. St Foix.
3	62·8	32·4	1·6	1·0	2·3*b*	100·1	v. Kobell, Greiner.
4	62·80	31·92	1·10	0·60	1·92*b*	98·34	Do. Katharinenburg.
5	63·0	33·6	trace	...	3·4	100·0	Delesse, Zillerthal.
6	62·50	35·44	2·02	...	0·04	100·0	Marignac (m. of 2), Chamouni.
7	63·95	28·25	0·60*c*	0·78	2·71*c*	100·23	Tengstrom, Ingeris, near Abo.
8	66·70	30·23	2·41	...	...	99·34	Lychnell, Mont Cannegou.
9	63·13	34·30	2·27	...	...	99·70	Do. Sala.
10	64·53	27·70	6·05	...	...	99·08	Do. Scotland.
11	66·53	33·42	trace	...	...	99·53	Do. China.
12	59·5	30·5	2·5*e*	...	5·5	98·0	Klaproth, Wunsiedel.
13	65·64	30·80	3·61	...	...	100·05	Lychnell, Do.
14	61·25	26·25	1·00*e*	1·00	6·00*f*	96·25	Vauquelin, Briancon chalk.
15	66·02	31·94	0·81	...	0·20*d*	99·72	Kersten, near Voightsberg.

(*a*) + 8·1 lime; (*b*) loss by heat; (*c*) + 3·94 volatile; (*d*) loss by heat + 0·75 soda and potash, with traces of chloride of sodium and sulphate of lime; (*e*) peroxide; (*f*) + 0·75 lime.

Talk, Nos. 1–6, and steatite (*Speckstein*), Werner, &c., Nos. 7–15, are, according to Lychnell's analyses, which show the latter to contain no water, only different forms of one mineral. The steatite is massive, of grey, red, yellow, or green colours. B.B. melts in fine splinters to a white enamel, but in other respects acts like talk. Some steatites are decomposed chlorite or other minerals, and though similar externally, are yet chemically distinct.

Talc not only forms talc-slate, but enters with quartz, mica, chlorite, and felspar into the composition of many other crystalline rocks. It is also common in subordinate beds, often containing cyanite and staurolite; or in veins, as of magnetic iron, copper pyrites, galena, and other ores, or is imbedded in limestone. Beautiful varieties occur at Greiner in Tyrol; Sala, Fahlun, and other places in Sweden; in the Pyrenees and many parts of the United States. Fine apple-green talc is found in Unst, one of the Shetlands; and talc-slate is

abundant in the Scottish Highlands. Steatite is a frequent pseudomorph after quartz or calc-spar, and is common in veins, as of tin ore at Schlaggenwald in Bohemia; in serpentine rocks, as at Göpfersgrün in Baireuth, and the Lizard Point, Cornwall; and in limestone, with fragments of encrinites, at Chapel Quarry, near Kirkcaldy, Scotland. Common talc is used as crayons for many purposes; also for polishing stones, and for forming crucibles and porcelain. Talc-slate is employed as a lining for ovens; and savage nations cut the steatite into culinary utensils.

Potstone or Topfstein is an uncertain mixture of talc, chlorite, mica, asbestus, and other minerals, and occurs in beds in various countries among crystalline rocks.

77. SCHILLERSPAR, *Jameson, Phillips;* Schillerstein, *Werner;* Diatomous Schiller-spar, *Mohs.*

Mono or tri-clinohedric, but only found granular and massive. Cleavage, very perfect in one direction, imperfect in another, meeting at 135°–140°. Fracture uneven, splintery; H. = 3·5 — 4; G. = 2·6 — 2·8. Translucent on thin edges. Lustre metallic pearly. Colour olive or pistacio green, yellow, brown, or black. Streak greenish-white. Imperfectly soluble in hydrochloric, wholly in sulphuric acid. B.B. becomes magnetic, and fuses in thin splinters on the edges. With borax fuses with difficulty to a glass, showing traces of iron when hot, of chrome when cold. Chem. com. perhaps $3\dot{R}^4\ddot{S}i^2 + \ddot{R}\ddot{S}i^2 + 10\dot{H}$. Analyses.

	Silica.	Magnesia.	Lime.	Iron protox.	Mang. protx.	Chrm. oxide.	Alumina.	Watr.	Total.	
1	43·90	25·86	2·64	13·02*a*	0·53	...	1·28	12·43	99·66	Köhler, Baste.
2	43·07	26 16	2·75	10·92	0·57	2·37	1·73	12·43	100	Do. Do.
3	42·36	28·90	0·63	13·27*a*	0·85	...	2·18	12·07	100·26	Do. Do.
4	41·48	27·24	...	16·61	...	...	6·49	10·13	101·95	Rammelsb., Radauthal.

(*a*) With chrome oxide.

In the formula given above, the iron is considered partly as the protoxide (with magnesia and lime = $\dot{R}$), partly the peroxide (with alumina and chrome-oxide = $\ddot{R}$). Rammelsberg deducts the chrome-oxide, alumina, and part of the iron as a mixture. The analyses distinguish it from hornblende and diallage, which it much resembles. The foliated variety, Nos. 1, 2, occurs in a compact rock, named schillerstein, of similar composition, No. 3 (not serpentine), found sparingly in the euphotide of the Harz, near Baste. No. 4 is a similar mineral from the Radauthal in the Harz. Other localities, named for this mineral, in Europe and North America, are still uncertain.

The true *Metaxite* of Breithaupt, from the Zweigler mine near

Schwarzenberg, is closely related. It is massive, asbestiform, weak pearly lustre, and greenish-white colour. H. = 2 — 2·5 nearly; G. = 2·52. Plattner found in it 43·60 silica, 34·24 magnesia, 6·10 alumina, 2·80 iron peroxide, and 12·67 water (= 99·41). In the closed tube it yields water; and B.B. fuses difficultly on thin edges to a brown enamel. In hydrochloric acid is wholly decomposed, leaving silica in powder.

78. ANTIGORITE, *Schweizer.*

Occurs in very thin, straight, slaty laminæ, which separate readily. H. = 2·5; G. = 2·62. Transparent or translucent; lustre weak; colour blackish-green in reflected, leek-green in transmitted light; in some parts with brown spots. Streak white. In closed tube gives water. B.B. on very thin edges fuses to a yellowish-brown enamel. After strong ignition becomes silvery white, with weak metallic lustre. Difficultly soluble in concentrated hydrochloric acid, leaving flakes of silica. Chem. com. $\dot{R}^4\,\ddot{S}i^3 + \dot{H}$, where $\dot{R}$ is magnesia and iron protoxide, but probably better $3\,\dot{R}\,\ddot{S} + \dot{M}g\,\dot{H}$. Analyses.

	Silica.	Iron prot.	Mag-nesia.	Alu-mina.	Watr.	Total.	
1	46·22	13·05	34·39	2·08	3·70	99·44	Schweitzer.
2	46·18	12·68	35·19	1·89	3·70	99·64	Do.

Probably from the Antigorio valley near Domo d'Ossola in Piemont.

79. HYDROPHITE, *Svanberg.*

Massive, with a fine columnar or fibrous structure. Fracture uneven. H. = 3 — 4; G. = 2·65. Colour mountain-green. Streak lighter. In closed tube yields water. B.B. infusible, but shows reaction for vanadic acid. Chem. com. nearly $(\dot{M}g\,\dot{F}e)^4\,\ddot{S}i^3 + 4\,\dot{H}$. Analysis.

	Silica.	Iron prot.	Mang. prot.	Mag-nesia.	Alu-mina.	Vanadic acid.	Water	Total.	
1	36·19	22·73	1·66	21·08	2·89	0·12	16·08	100·75	Svanberg.

Found in the magnetic iron ore of the Taberg, Sweden.

80. SERPENTINE, *Werner, Hauy, Jameson, Phillips, &c.*; Ophite, *von Leonhard;* Prismatic Serpentine-steatite, *Mohs.*

Crystallization uncertain; though Haidinger describes some imperfect rhombic forms, and others have been noticed by Beck in

New York. Generally massive, and indistinctly granular or fibrous. Occurs in veins or imbedded masses, or as a pseudomorph after chrysolite, augite, &c. Fracture flat-conchoidal, uneven, or splintery. Sectile and slightly brittle. H. = 3 — 3·5; G. = 2·5 — 2·6. Translucent to opaque. Lustre dull. Colour various shades, generally dark, of green, grey, yellow, red, or brown, often in spots, stripes, or veins. Streak white, shining. Feels greasy. In the closed tube yields water and becomes black. B.B. becomes white, and fuses with much difficulty on thin edges. With borax forms a green glass, and with salt of phosphorus leaves silica. With solution of cobalt becomes pale-red. Soluble in hydrochloric, or better in sulphuric acid. Chem. com. $\dot{M}g^3\ddot{S}i^2 + 2\dot{H} = 44{\cdot}02$ silica, 43·11 magnesia, and 12·87 water, part of the magnesia being replaced by iron protoxide. Analyses.

	Silica.	Magnesia.	Iron prot.	Alumina.	Water.	Carb. acid and Bitumen.	Total.	
1	41·67	41·25	1·64	...	13·80	1·37	99·73	Lychnell, Hoboken.
2	41·66	37·16	4·05	...	14.72	...*a*	99·84	Stromeyer, Philipstad.*
3	42·97	41·66	2·48*b*	0·87	12·02*c*	...	100	Hartwall, Snarum.
4	40·71	41·48	2·43	2·39	12·61	...	99·62	Scheerer, Do.
5	42.34	44·20	...	...	12·38	0·89*d*	99·81	Mossander, Gullsjö.
6	40·93	33·44	8·72	0·73	12·66	1·73	98·46	Lychnell, Taberg,
7	42.16	42·26	1·98	...	12·23	1·03	99·66	Do, Sala.
8	43·20	40·09	5·24	...	11·42	...	99·95	Do. Massachusetts.
9	43·73	37·72	6·11	0·81	11·63	...	100	Schaffgotsch, Gormoschit, Ural.
10	40·52	42.05	3·01	0·21	13·85	0·30*e*	99·94	Marchand, Fahlun.
11	40·80	40·50	2 20	3·02	12·02	...*f*	97·16	Ivanoff, Ural.
12	41·50	40·34	4·10	...	12·87	...*g*	99·73	Kersten, Schwarzenberg.†
13	43·79	41·03	2·05	...	12·47	...	99·34	Rammelsberg, Texas.‡

(*a*) + 2.25 manganese peroxide; (*b*) peroxide; (*c*) with carbonic acid; (*d*) carb. acid; (*e*) carbonaceous matter; (*f*) + 0·20 manganese protoxide, and 0·42 lime; (*g*) + 0.50 manganese protoxide, and 0·42 soda.

* In Wermeland. † In Saxony. ‡ In Lancaster County, Pennsylvania.

There are very many other analyses of this mineral which may be found in Rammelsberg. That chemist has selected the above on which to base a formula, and finds the average oxygen in $\dot{M}g + \dot{F}e : \ddot{S}i\ (+ \ddot{A}i) : \dot{H}$ to be as 9·2 : 42 : 6·1, or 3 : 4 : 2, which gives the above simple formula. Some contain a small proportion of chrome-oxide, 2·00 in one from Vermont, Jackson; and a bright yellow serpentine from Åsen, 2·24 of cerium-protoxide, Lychnell.

The supposed crystals of this mineral are not improbably merely pseudomorphs, as those from Snarum in Norway of olivine. Several varieties of it hav been distinguished. 1st, Noble Serpentine, generally with smooth conchoidal fracture; translucent; lustre dull, but resinous when polished; and sulphur-yellow, siskin, leek or mountain-green, or greenish and yellowish-white colours (analyses Nos.

3, 10). 2d, Marmolite or foliated serpentine, of pale-green, yellow, or grey colours, with, it is said, a monoclinohedric cleavage in two oblique planes (analysis No. 1). 3d, Picrolite or fibrous serpentine, translucent only on the edges, harder than noble serpentine (H. = 3·5 — 4·5), and of dirty-leek or mountain-green, more rarely brown colours (anal. 2, 6). 4th, Common or compact serpentine, dark-coloured, opaque, with a dull splintery fracture.

5th, *Chrysotile* of von Kobell (*Baltimorite*, Thomson; *Metaxite*, Delesse and Kühn), in fine parallel asbestiform fibres, easily separated with olive or oil green, yellow brownish colours, and a metallic or silky lustre. Delesse considers it a distinct mineral, identical with serpentine in composition, but distinguished by its form and lower specific gravity = 2·219. Analyses.

	Silica.	Magnesia.	Iron protox.	Alumina.	Watr.	Total.	
1	43·50	40·00	2·08	0 40	13·80	99·78	v. Kobell, Reichenstein.
2	40·95	34·70	10·05	1·50	12·60	99·80	Thomson, Baltimore.
3	42·1	41·9	3·0	0·4	13·6	100	Delesse, Reichenstein.
4	44·48	40·60	2·34	...	12·35	99·77	Kühn, Do.

Common serpentine alone, or more or less intimately mixed with euphotide, diabase, crystalline limestone, and dolomite, forms whole mountains. It occurs in many countries, as at the Lizard Point in Cornwall, in Shetland, and the Highlands of Scotland. Noble serpentine and picrolite form nests or veins in common serpentine, in granular limestone, or in magnetic iron, copper pyrites, and other ores. They are common in Norway, Sweden, North America, and at Portsoy in Scotland. The chrysotile was first known from Reichenstein in Silesia (*schillernder Asbest*), but since in the Vosges Mountains and North America. Serpentine rock contains many minerals, as the pyrope, bronzite, diallage, brucite, and especially metals or ores, as platinum, chrome ore, arsenical pyrites, and magnetic iron ore.

Serpentine is often cut into various ornamental articles, as it can be readily wrought on the lathe. It was formerly exported from Portsoy for such purposes. The rock is very durable unless when mixed with iron pyrites.

81. PICROSMINE, *Haidinger*; Prismatic Picrosmine-steatite, *Mohs*. Rhombic, but only massive, in granular or columnar aggregates. Cleavage, brachydiagonal perfect, macrodiagonal less perfect, prismatic along ∞P 126° 52′, and macrodomatic along P∞ 117° 49′ imperfect. Very sectile; H. = 2·5 — 3; G. = 2·5 — 2·7. Translucent on the edges or opaque. Vitreous, but pearly on ∞P∞.

Greenish-white or grey, mountain, olive, or blackish-green. Streak colourless. Yields a bitter odour when breathed on (hence the name). In closed tube gives water and blackens. B. B. becomes white, opaque, and hard (= 5). Fusible with borax, and in salt of phosphorus leaving a siliceous skeleton; in cobalt solution becomes slightly red. Chem. com. $2\,\dot{M}g\,\ddot{S}i + \dot{H} = 62$ silica, 40 magnesia, and 9 water. Analyses.

	Silica.	Magnesia.	Alumina.	Iron perox.	Mang. protoxide.	Water.	Lime.	Total.	
1	54·89	33·35	0·79	1·40	0·42	7·30 *a*	...	98·15	Magnus, Presnitz
2	56·17	31·53	...	8·56 *b*	...	4·04	...	100·40	A. Erdmann, Bergenstift.
3	49·80	30·10	1·11	6·86 *b*	trace	9·83	0·78	98·48	Svanberg, Sala.

(*a*) With a little ammonia; (*b*) protoxide.

Picrosmine (No. 1) is found with magnetic iron in a bed in gneiss in the Engelburg near Presnitz, Bohemia. Also at the Greiner in Tyrol, in talc or chlorite slate; and near Waldheim in Saxony, as veins in serpentine.

Monradite of Erdmann (No. 2), from Norway, massive, foliated, translucent, and yellowish-grey. H. = 6; G. = 3·267, has nearly the same composition, but with half the water, or 3 ($\dot{M}g$, $\dot{F}e$) $\ddot{S}i + \dot{H}$. B.B. is infusible, but becomes darker.

The *Picrophyll* of Svanberg (No. 3), in dark-green foliated masses, with G. = 2·73; H. = 2·5. B.B. infusible, but becoming white, is also nearly related. Chem. com. $3\,\dot{M}g\,\ddot{S}i + 2\,\dot{H}$.

82. Villarsite, *Dufrénoy.*

Rhombic; crystals formed by $\infty P \,.\, P \,.\, 0P$, with $\infty P = 119°\ 59'$ (?). Also massive and granular. Fracture uneven; H. = 3; G. = 2·9 — 3. Translucent; greenish or greyish-yellow. B.B. infusible alone; with borax forms a green enamel. Decomposed by strong acids. Chem. com. $2\dot{M}g^2\,\ddot{S}i + \dot{H}$ with 41 silica, 53 magnesia, and 6 water. Analyses.

	Silica.	Magnesia.	Iron protox.	Mangan. protox.	Lime.	Potash.	Watr.	Total.	
1	39·40	45·33	4·30	2·86	0·54	0·46	5·80	98·69	Dufrénoy.
2	39·61	47·37	3·59	2·42	0·53	0·46	5·80	99·78	Do.

Chemically this mineral is a hydrous olivine, but in other characters resembles serpentine. The crystallized serpentine from Pennig, described by Haidinger, had nearly the same angles, and probably

was this mineral. It occurs in beds of magnetic iron ore at Traversella in Piemont.

83. SPADAITE, *v. Kobell.*

Cryptocrystalline or amorphous; only found massive, with an imperfect conchoidal and splintery fracture. Sectile. H. = 2·5. Translucent; weak resinous lustre; colour red; streak white. In closed tube yields water, and becomes grey. B.B. fuses to an enamel-like glass. Easily soluble in concentrated hydrochloric acid, leaving slimy silica. Chem. com. $\dot{M}g^5\ddot{S}i^6 + 4\dot{H}$, with 57 silica, 32 magnesia, and 11 water. Analyses.

	Silica.	Magnesia.	Iron protox.	Alumina.	Watr.	Total.	
1	56·00	30·67	0·66	0·66	11·34	99·33	v. Kobell.

Occurs at Capo di Bove, near Rome.

84. GYMNITE, *Thomson.*

Only found massive; softer than felspar; G. = 2·216. Semi-translucent; lustre resinous; colour pale or dirty orange-yellow. B.B. emits water, and becomes dark-brown. With solution of cobalt rose-red; with borax fuses to a colourless glass. Chem. com. $\dot{M}g^4\ddot{S}i^3 + 6\dot{H}$ = 41 silica, 36 magnesia, and 23 water. Analysis.

	Silica.	Magnesia.	Alumina.	Lime.	Watr.	Total.	
1	40·16	36·00	1·16	0·80	21·60	99·72	Thomson.

Named from the Bare Hills, near Baltimore, where it is found. The alumina showed traces of iron.

85. CHONIKRITE, *v. Kobell.*

Massive. Fracture uneven. Sectile. H. = 2·5—3; G. = 2·91. Translucent or only on the edges. Lustre dull or glimmering. Colour snow, yellowish, or greyish white. In closed tube yields water. B.B. melts with ebullition to a greyish-white glass. With solution of cobalt blue. Soluble with deposition of silica in hydrochloric acid. Chem. com. $5\,(\dot{M}g, \dot{C}a, \dot{F}e)^2\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i + 6\,\dot{H}$. Analysis.

	Silica	Alumina.	Magnesia.	Lime.	Iron prot.	Watr.	Total.
1	35·69	17·12	22·50	12·60	1·46	9·00	98·37

Occurs on Elba in veins of serpentine; but is perhaps, as Berzelius conjectured, a mixture.

86. Pyrosklerite, *v. Kobell.*

Rhombic? but only massive, with cleavage, in two directions at right angles, the one perfect, the other imperfect. Fracture uneven splintery. Sectile. H. = 3; G. = 2·7 — 2·8. Translucent; lustre dull, or on the cleavage planes weak pearly. Colour apple, emerald, or greyish-green. Yields water in closed tube. B.B. fuses with difficulty to a grey glass. With borax forms a chrome-green glass. The powder soluble in concentrated hydrochloric acid, leaving silica. Chem. com. $3\,\dot{M}g^2\,\ddot{S}i + \ddot{A}l\,\ddot{S}i + 4\,\dot{H}$. Analyses.

	Silica.	Magnesia.	Alumina.	Iron prot.	Chrome oxide.	Water.	Total.	
1	37·03	31·62	13·50	3·52	1·43	11·00	98·10	v. Kobell.
2	35·28	35·35	13·73	1·79	...	7·33*a*	99·76	Lychnell.

(*a*) + 6·28 bitumen and carbonic acid.

No. 1 is the pyrosklerite found with chonikrite in Elba. No. 2 is a greyish-yellow serpentine from Aker in Södermanland, G. = 2·605, which v. Kobell and Berzelius unite with this mineral. Scheerer would conjoin pyrosklerite with chonikrite.

87. Kammererite, *v. Wörth.*

Hexagonal; 0P . ∞P tabular and prismatic; but usually massive and granularly foliated. Cleavage, basal perfect. Sectile, flexible. H. = 1·5 — 2; G. = 2·76. Translucent; lustre pearly. Colour violet-blue, reddish, or greenish. Feels greasy. In the closed tube gives water. B.B. exfoliates without fusing. With salt of phosphorus leaves silica, and forms a glass brown when hot, and green when cold. Cobalt solution colours it partly blue. Chem. com. identical with pyrosklerite, except one atom more water (5 $\dot{H}$). Analysis.

	Silica.	Alumina.	Chrome oxide.	Magnesia.	Lime.	Iron prot.	Watr.	Total.	
1	37·0	14·2	1·0	31·5	1·5	1·5	13·0	99·7	Hartwall.

Occurs with chromate of iron at Bissersk in Siberia. Though agreeing so nearly in chemical composition with pyrosklerite, it differs much externally, and more resembles the hydrargillite.

The *Rhodochrome* of Fiedler agrees closely with kammererite. It is massive, fine scaly, with a splintery fracture. H. = 2·5 — 3; G. = 2·668. Colour greenish-black, in fine splinters peach-blossom red. B.B. gives out water, and melts on thin edges to a yellow enamel.

With borax forms a green glass. Difficultly soluble in hydrochloric acid. Chem. com. silica, magnesia, chrome oxide, with a little alumina and water. Occurs on the island Tino in Greece, Kyschtimsk in Ural, Kraul in Styria, and near Baltimore, along with chromate of iron.

88. PYROSMALITE, *Hausmann*, *Phillips*; Fer muriaté, *Hauy*; Axotomous pearl mica, *Mohs*.

Hexagonal; P 115° 37'; crystals chiefly ∞P. 0P, prismatic or tabular, but sometimes with faces of P or other pyramids. Also massive and granular. Cleavage, basal perfect; prismatic along ∞P imperfect. Brittle: H. = 4 — 4·5; G. = 3·0 — 3·2. Translucent to opaque. Lustre resinous, metallic pearly on 0P. Liver-brown to olive-green. In the closed tube yields water and then yellow drops of chloride of iron. B.B. fuses to a black magnetic globule. With borax and salt of phosphorus, shows reaction for iron, and manganese; with salt of phosphorus and copper-oxide for chlorine. Wholly soluble in concentrated nitric acid. Chem. com., according to L. Gmelin, $15\dot{F}e\,\ddot{S}i + 15\dot{M}n\,\ddot{S}i + 3\ddot{F}e\,\dot{H} + Fe^2\,Cl^3 = 38{\cdot}5$ silica, 22 iron protoxide, 22 manganese protoxide, 13 iron peroxide, 3·4 hydrochloric acid, and 1·1 water. Analyses.

	Silica.	Iron perox	Manganese.	Alumina.	Lime	Hydr. acid.	Watr.	Total.	
1	35·40	32·60	23·10	0·60	...	6·50 ...		98·20	Hisinger.
2	35·85	35·48	23·44	...	1·21	29·15	undt.	98·8	Do.
3	35·85	21·81	21·14*a*	...	1·21	14·09*b*	5·90*c*	100	No. 2 by Rammelsberg.

(*a*) Protoxide; (*b*) chloride of iron; (*c*) water and loss.

No. 3 is Rammelsberg's interpretation of analysis No. 2 on the supposition that the chlorine forms a basal salt with iron. It occurs with calc-spar and hornblende in magnetic iron-ore in the Bjelkey-grube, near Nordmark (Nos. 1, 2), and at Nya Kopparberg, in Sweden.

89. CRONSTEDTITE, *Steinmann*; Chloromelan, *Naumann*; Rhombohedric Melan-mica, *Mohs*.

Rhombohedric, perhaps hemimorphic, chiefly in radiated, columnar groups, sometimes ending in hexagonal prisms. Cleavage, basal perfect; cleavage planes slightly convex; thin laminæ elastic. H. = 2·5; G. = 3·3 — 3·5. Opaque or translucent. Highly vitreous. Raven-black; streak dark-green. B.B. intumesces, and melts on the edges slowly to a black glass (to a steel-grey globule, *v. Kobell*). With borax forms a glass coloured by iron. Gelatinizes with hydro-

chloric or sulphuric acid. Chem. com. $\dot{\ddot{F}}\dot{e}^2\,\ddot{S}i + 2\dot{F}e^2\,\ddot{S}i + 5\,\dot{H}$, but part of the iron protoxide often replaced by magnesia. Analyses.

	Silica.	Iron perox.	Iron protox.	Mang. perox.	Magnesia.	Water.	Total.	
1	22·45	...	58·85	2·89	5·08	10·70	99·97	Steinmann, Przibram.
2	22·45	35·35	27·11	2·89	5·08	10·70	103·58	Do. cor. by v. Kobell.
3	16·3	...	75·5*a*	...	4·1*b*	7·3	103·2	Wernekink.

(*a*) Protoperoxide; (*b*) alumina.

The cronstedtite occurs with iron pyrites, calc-spar, and iron ores, in the silver mines of Przibram in Bohemia; also at Wheal Maudlin, Cornwall. The *Sideroschisolite* of Wernekink (No. 3), found with iron ores at Conghonas do Campo in Brazil, agrees in external aspect, and is perhaps identical. B.B. very easily fusible (Wernekink); infusible (Berzelius). The analysis was performed with only three grains of the mineral, which may account for the difference.

90. Stilpnomelan, *Glocker.*

Crystallization unknown; massive and disseminated, with a granular or radiating-foliated texture. Cleavage in one direction very perfect. Rather brittle. H. = 3 — 4; G. = 3 — 3·4 (2·76 *Breithaupt.*) Opaque; lustre vitreous, inclining to pearly on the cleavage planes. Colour greenish-black to blackish-green; streak olive-green to greenish-grey. In closed tube yields water. B.B. fuses with difficulty to a black shining globule, and with fluxes shows reaction for iron and silica. Imperfectly decomposed by acids. Chem. com. $6\,\dot{F}e\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^3 + 6\,\dot{H} = 46{\cdot}5$ silica, 36 iron protoxide, 8·5 alumina, and 9 water. Analyses.

	Silica.	Iron protox.	Alumina.	Lime.	Magnesia.	Water.	Potash.	Total.	
1	43·19	37·05	8·16	1·19	3·34	5·95	...	98·88	Rammelsberg.
2	46·50	33·89	7·10	0·20	1·89	7·90	...	97·48	Do.
3	45·43	35·38	5·88	0·18	1·68	9·28	...	97·83	Do.
4	46·17	35·82	5·88	...	2·67	8·72	0·75	100	Do.

Occurs with calc-spar, quartz, and iron pyrites, in clayslate at Obergrund in Austrian Silesia. R. thinks the specimen analysed mixed perhaps with chlorite.

91. Brucite, *Beudant;* Native Magnesia, *Bruce, Jameson;* Hydrate of Magnesia, *Brewster, Phillips;* Magnésie hydratée, *Hauy;* Talk hydrat, *v. Leonhard;* Rhombohedral Kuphonmica, *Mohs.*

Hexagonal; 0P . ∞P, also massive, foliated, or columnar. Cleav-

age, basal very perfect. Sectile, in fine laminæ flexible; H. = 2; G. = 2·3 — 2·4. Semitransparent or translucent; lustre pearly; colourless, or greyish and greenish-white. By friction becomes positively electric (Hauy). In the closed tube yields water. B.B. infusible alone, with cobalt solution becomes pale-red. Easily soluble in acids. Chem. com. $\dot{M}g\ \dot{H}$ with 69 magnesia, and 31 water. Analyses.

	Magnesia.	Water.	Mang. perox.	Iron protox.	Lime.	Total.	
1	69·75	30·25	...	...	...	100·0	Fyfe, Unst.
2	67·98	30·96	1·57		...	100 51	Thomson, do.
3	66·67	30·39	1·57	1·18	0·19	100	Stromeyer, do.
4	68·34	30·90	0·64	0·12	...	100	Do. Hoboken.
5	70	30	...	...	...	100	Bruce, do.
6	64·0	29·0	...	2·5	2·0*a*	97·5	Vauquelin, do.

(*a*) Silica.

G. Rose finds that perfectly pure transparent fragments effervesce in hydrochloric acid, and infers that this mineral contains carbonic acid. At all events it gradually acquires this on exposure, becoming dull and pulverulent. It is found in veins in serpentine, at Swinaness in Unst, Zetland, at Hoboken in New Jersey, and at Pyschminsk, near Beresowsk in Siberia.

92. Hydromagnesite, *v. Kobell.*

Cryptocrystalline or amorphous. Occurs in roundish masses, with an earthy or imperfect conchoidal fracture; H. = 1·5 — 2; G. unknown. Lustre dull, colour white. Feels greasy, and leaves a mark on paper. B.B. is infusible. In closed tube gives out water and acts like pure magnesia. Soluble with effervescence in acids. Chem. com. $\dot{M}g^4\ \dot{C}^3 + 4\ \dot{H}$ with 36·2 carbonic acid, 44·0 magnesia, and 19·8 water. Analyses.

	Carbonic acid.	Magnesia.	Watr.	Silica.	Iron perox.	Veinstone.	Total.	
1	36·02	42·41	18·53	0·57	0·27	1·39	99·99	Trolle-Wachtmeister, Hoboken.
	36·00	43·96	19·68	0·36	...	...	100	v. Kobell, Kumi.
2	33·10	24·28	17·40	...	25 22*a*	...	100	Do. Vesuvius.

(*a*) Lime.

This mineral is thus identical with the magnesia alba of chemists. It is found in serpentine at Hoboken in New Jersey, with brucite, probably as a produce of its decomposition, and at Kumi on Negroponte in Greece. Also it is said in the East Indies. No. 3 is the *Hydromagnocalcite* of Rammelsberg, a kind of sinter found in yellowish-

white spherical masses on Vesuvius, and which may be regarded as hydromagnesite with the magnesia partly replaced by lime.

93. Nemalite, *Nuttal.*

Occurs in fine elastic asbestiform fibres; H. = 2; G. = 2·4. Lustre silky; colour white, greyish, or yellowish. B.B. acts like brucite; slowly decomposed by acids slightly effervescing. Chem. com. by Connell's analysis $5\,\dot{M}g\,\dot{H} + (\dot{M}g\,\ddot{C} + \dot{H})$ = 61·36 magnesia, 11·19 carbonic acid, and 27·45 water. Analyses.

	Magnesia.	Silica.	Iron perox.	Iron protox.	Water.	Carbonic acid.	Total.	
1	51·72	12·57	5·87	...	29·67	...	99·83	Thomson, Hoboken.
2	57·80	0·80	...	2·84	27·96	10·00	99·46	Connell, Do.

Forms veins in serpentine at Hoboken in New Jersey, and in greenstone at Piermont, New York, and Bergen Hill, New Jersey. The mineral analysed by Thomson seems a distinct species, with chem. com. $4\,\dot{M}g\,\dot{H}^{2} + \dot{M}g^{2}\,\ddot{S}i$.

94. Seybertite, *Clemson;* Holmesite, *Thomson;* Clintonite, *Dana;* Xanthophyllite, *G. Rose;* Chrysophane, *Breithaupt;* Rhombohedric pearl-mica, *Mohs.*

Crystalline, probably hexagonal. Sometimes in hexagonal tables; usually massive and coarsely foliated. Cleavage very perfect in one direction; traces in another; H. = 4·5 — 6; G. = 3. — 3·16. Translucent or transparent in thin foliæ; pearly on the cleavage planes; wax-yellow, yellowish, or reddish-brown. Soluble in concentrated acids, but the xanthophyllite with difficulty in warm hydrochloric acid. B.B. infusible alone, but some become white and colour the flame yellow. Chem. com. uncertain. Analyses.

	Silica.	Alumina.	Magnesia.	Lime.	Iron perox.	Soda.	Watr.	Total.	
1	17·0	37·6	24·3	10·7	5·0*a*	...	3.6	98·2	Clemson.
2	19·35	44·75	9·05	11·45	4·80	...*b*	4.55	98·25	Richardson.
3	21·4	46·7	9·8	12·5	4·?	...	3.5	98·2	Plattner.
4	16·30	43·05	19·31	13·26	2·53*a*	0·61	4.33	100·29	Meitzendorf.
5	20·00	43·22	25·01	4·00	3·60	0·57	3.60	100	v. Kobell.

(*a*) Protoxide; (*b*) + 1·35 manganese protoxide, 2·05 zirconia, and 0·90 fluoric acid.

The Seybertite (Nos. 1, 2, 3) occurs in granular limestone near serpentine at Amity, New York. The Xanthophyllite (No. 4, mean of four), along with magnetic iron ore in talc state, near Slatoust in the Ural.

The *Disterrite* of Breithaupt (No. 5), from Monzoni in the Fassathal,

Tyrol, occurs in hexagonal tables with basal cleavage perfect, but difficult to obtain. H. = 5 on basis, 6 — 6·5 on the prism; G. = 3·04 — 3·05. Translucent; lustre pearly; colour when fresh blackish-green, but reddish-brown after exposure. B.B. infusible, but becomes greyish-white. Dissolves slowly in borax or salt of phosphorus. Not soluble in hydrochloric acid, but after long boiling in concentrated sulphuric acid. The above minerals, if distinct, are closely allied species (connecting the silicates and aluminates, *v. Kobell*).

95. MARGARITE, *Fuchs;* Pearl-mica, *Jameson;* Hemiprismatic Pearl-mica, *Mohs.*

Monoclinohedric of unknown dimensions. Rarely crystallized in six-sided tables, formed of 0P . ∞P . (∞P∞). Generally granular foliated. Cleavage, basal very perfect. Thin plates slightly elastic. H = 3·5 — 4·5; G. = 3·032. Translucent; lustre vitreous, or pearly on cleavage planes; snow-white, reddish-white, or pearl-grey. B.B. intumesces and difficultly fusible. Soluble in acids. Chem. com. uncertain. Analyses.

	Silica.	Alumina.	Iron perox.	Mangan protox.	Lime.	Magnesia.	Soda.	Watr.	Total.	
1	37·00	49·50	4·50	...	8·96	...	1·24	1·00	93·20	Dumenil.
2	33·50	53 00	0·42*a*	0·03	7·50	0·05	...	...	99·50	Göttingen laboratory.

(*a*) Protoxide.

Occurs at Sterzing in Tyrol with chlorite. Dumenil's analysis is very imperfect. No. 2 is given by Hausmann.

96. PYROPHYLLITE, *Hermann.*

Probably rhombic, but crystals very indistinct. Massive and radiated columnar or foliated. Cleavage very perfect parallel to the columnar structure. Flexible in thin plates. Sectile, H. = 1; G. = 2·7 — 2·8. Translucent; pearly; colour, light verdigris-green to greenish or yellowish-white. In closed tube yields water, and becomes silvery. B.B. in the forceps exfoliates and swells up with many twistings to a snow-white infusible mass. With cobalt solution becomes blue. Partially soluble in sulphuric acid. Chem. com. uncertain. Analyses.

	Silica.	Alumina.	Magnesia.	Iron perox.	Water.	Silver.	Total.	
1	59·79	29·46	4·00	1·80	5·62	trace.	100·67	Hermann, Ural.
2	66·14	25·87	1·49	...	5·59	0·39 *b*	99·48	Rammelsberg, Span.
3	49·03	2·78	16·96	16·12 *a*	10·28	...	99·72	Thomson, Vermont.

(*a*) Protoxide; (*b*) lime.

The pyrophyllite (Nos. 1, 2), formerly considered talc, occurs in quartz veins in the beresite or granite, between Beresowsk and Pyschminsk, in the Ural, and also near Spaa. No. 3 is the *Vermiculite* of Thomson, which resembles a fine scaly talc, and B.B. acts like pyrophyllite. It is found at Millbury, Mass., and in Vermont, North America. These substances are probably mere products of the decomposition of other minerals; and the vermiculite is said by Dana to be a mechanical mixture.

97. ANAUXITE, *Breithaupt.*

Massive and granular, with a very perfect cleavage in one direction. H. = 2 — 3; G. = 2·26. Translucent on the edges; lustre pearly, colour greenish-white. In the closed tube gives water, and blackens. B.B. becomes white, and fuses on thin edges. With cobalt solution blue. Chem. com. by an imperfect analysis of Plattner, 55·7 per cent. silica, much alumina, a little magnesia, iron protoxide, and 11·5 per cent. water. Occurs at Bilin, Bohemia.

98. PHOLERITE, *Guillemin*; Nacrite, *Vauquelin?*

Cryptocrystalline, massive, and fine scaly. H. = 0·5 — 1; G. = 2·35 — 2·57. Lustre glimmering or pearly. Colour snow-white or yellowish-white. In closed tube gives water. B.B. infusible; becomes blue with cobalt solution. Chem. com. $\ddot{A}i^2\,\ddot{S}i^3 + 4\,\dot{H}$. Mean of three analyses by Guillemin, from Fins in the Allier dept., 41·78 silica, 43·10 alumina, and 15·12 water. The nacrite of Vauquelin was probably mica; that analysed by Thomson a variety of talc.

99. ROSELLAN, *Svanberg*; Rosite, *Hausmann.*

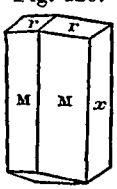
Occurs in small grains imbedded in limestone. Cleavage in one direction perfect. H. = 2·5; G. = 2·72. Translucent; lustre splendent on cleavage planes. Colour fine rose red; streak white. In closed tube gives out water and loses its colour. B.B. fuses with difficulty to a white slag; with soda fuses readily. Chem. com. $\ddot{A}i^2\,\ddot{S}i^3 + \dot{R}\,\ddot{S}i + 2\,\dot{H}$. Svanberg found 44·90 silica, 34·51 alumina, 0·69 iron peroxide, 0·19 manganese peroxide, 3·59 lime, 2·45 magnesia, 6·63 potash, and 6·53 water (= 99·48). Occurs at Åker and Baldurstad in Södermanland, Sweden.

VIII. Family.—Hornblende.

100. Hornblende, *Werner, Phillips, &c.;* Amphibole, *Hauy, &c.;* Hemiprismatic Augite-spar, *Mohs.*

Monoclinohedric; C = 75°, ∞P 124° 30′, P 148° 30′. The crystals are partly short and thick, partly long and thin prismatic, formed especially by ∞P (*M*) and (∞P∞) (*x*), and bounded on the ends chiefly by 0P and P (*r*), or also by (P∞) 148° 16′. Fig. 129 is a very characteristic form. The crystals are imbedded, or attached, and in druses. Macles are common, united by a face of the orthopinakoid, and the chief axis the twin axis. Very often massive, in radiated, parallel, or confused fibrous or columnar aggregates, or in coarse or fine granular masses. Cleavage, prismatic along ∞P very perfect, orthodiagonal and clinodiagonal very imperfect. H. = 5 — 6; G. = 2·9 — 3·4. Pellucid in all degrees. Lustre vitreous, but sometimes pearly or silky. Colourless; often white, but usually some shade of grey, yellow, green, brown, or black. B.B. fuses, generally intumescing and boiling, to a grey, green, or black glass. Those containing most iron are most fusible, and are also partially soluble in hydrochloric acid, which scarcely affects the others. Chem. com. very variable, and hardly reducible to any general formula. L. Gmelin gives $\dot{R}^5 \ddot{S}i^6$, or $3\ \dot{R}\ \ddot{S}i + \dot{R}^2\ \dot{S}i^3$, as the basis of all hornblendes; $\dot{R}$ being essentially magnesia and lime in variable proportions, and occasionally replaced by protoxide of iron. Some contain fluoride of calcium; very many, especially the green and black varieties, a considerable amount of alumina. Analyses, next page.

Fig. 129.



These analyses,—and many others might be added,—show the variations in composition to which this mineral is liable. The most important is in alumina, which may either form an aluminate mixed in indefinite proportion with the silicates, or perhaps replaces a portion of the silica. Rammelsberg has found that the oxygen of the bases in Nos. 5, 17, 20, 21, 22, 23, 24, is to that of the silica and alumina combined as 4 : 9 nearly, which he regards as the atomic proportion of the pure silica hornblendes, and it is still nearer 5 : 12, the proportion assumed above from L. Gmelin. Hence the latter view seems the more probable.

In external aspect the mineral also shows much diversity, giving rise to varieties often considered species, and described as such. The following are the more remarkable :—

1. *Tremolite,—Grammatite* or *Calamite*, white, grey, green, rarely

	Silica.	Magnesia.	Lime.	Iron prot.	Mang. prot.	Alumina.	Fluor. acid.	Watr.	Total.	
1	60·10	24·31	12·73	1·00	0·47	0·42	0·83	0·15	100·01	Bonsdorff, Fahlun.
2	59·75	25·00	14·11	0·50	...	trace.	0·94	0·10	100·40	Do. Gulsjo.
3	59·5	26·8	12·3	trace	...	1·4	...	...	100·00	Beudant, Cziklowa.
4	58·07	24·46	12·99	1·82	...	...	...	...	97·34	Damour, St Gotthardt.
5	47·21	21·86	12·73	2·28	0·57	13·94	0·90	0·44	99·93	Bonsdorff, Aker.
6	59·75	21·10	14·25	3·95	0·31	...	0·76	...	100·12	Do. Taberg.
7	59·50	19·30	12·65	8·60	...	...	...	...	100·05	Murray, Do.
8	58·20	22·10	15·55	3·08	0·21	0·14	0·60	0·14	100·03	Bonsdorff, Tarantaise.
9	58·19	30·79	...	7·93	...	0·18	...	1·86*b*	98·95	Heintze, Ural.
10	58·49	31·38	0·04	9·22		0·88	...	...	100	Lappe, Koruk, Greenland.
11	57·98	22·38	12·95	6 32	...	0·58	...	...	100·21	Rammelsberg, Kuhnsdorff
12	56	23	2	1 3	4	3	...	...	101	L. Gmelin, Kongsberg.
13	56·74	24·35	...	13·94	2·38	...	...	1·67	99·08	Vopelius, Do.
14	40·27	13·38	13·80	15·34*a*	...	16·36	...	0·46	99·61	Göschen, Cernosin.
15	44·03	2·33	10·00	25·55*a*	...	14·31	...	3·44	99·74	Madrell, Do.
16	47·62	14·81	12·69	15·76	0·32	7·38	...	...	98·60	Hisinger, Fahlun.
17	45·06	16·74	13·36	7·92	1·67	13·51	...	0·22	98·46	Do. Lindbo (m. of 2).
18	53·50	4·65	11·35	22 25	0·35	4·40	...	0·60	97·10	Do. Garpenberg.
19	41·50	19·40	14·09	7·75	0·25	13·75	...	0 50	97·24	Do. Pargas.
20	45·69	18·79	13·83	7·32	0·22	12·18	1·50	...	99·53	Bonsdorff, Do.
21	48·83	13·61	10·16	18·75	1·15	7·48	0·41	0·50	100·89	Do. Nordmark.
22	49·07	20·20	10·33	9·77	...	9·24	...	...	98·70	Kudernatsch, Kongsberg.
23	45·31	14.28*d*	10·49	15·93	...	11·88	0·66*e*	...	98·55	Do. Veltlin.
24	42·24	13·74	12·24	14·59	0·33	13·92	...	...	97·06	Bonsdorff, Wetterau.
25	40·08	13·50	11·01	13·69*a*	...	17·59	1·10	0·18*f*	100	Struve, Bilin.
26	46·03	18·48	10·23	17·44	...	8·37	...	...	100·55	Clausbruch.
27	49·27	0·42	1·50	36·12	0·62*a*	2·00	... *g*	...	98 17	v. Kobell, Greenland.
28	50·51	...	1·56	31·55	8·92*a*	2·49	...	0·96	25·97	Thomson, Faroe.
29	46·57	5·88	5·91	24·38	2·07	3·41	... *h*	...	100 99	Plantamour, Brevig.

(*a*) Peroxide; (*b*) loss by heat; (*c*) protoperoxide; (*d*) with manganese; (*e*) titanic acid and silica; (*f*) + 1·89 potash, and 0·96 soda; (*g*) + 8·00 soda with traces of potash, and 0·24 chlorine; (*h*) + 7.79 soda, 2 96 potash, 2·02 titanic acid, and fluorine not determined.

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yellowish or blue; in long prismatic crystals of ∞P. ∞P∞, or in columnar aggregates. The crystals often bent and striated longitudinally. Lustre pearly or silky; semitransparent or translucent; B.B. fuse readily to a white or nearly colourless glass; analyses, No. 1—5 above. Chem. com. of No. 1 and 2 nearly 3 $\dot{M}g^{5}\dot{S}i^{6} + \dot{C}a^{5}\dot{S}i^{6} + Ca\,F$. Occurs chiefly disseminated in dolomite, granular limestone, or other subordinate beds in the crystalline rocks; rarely in veins. With magnetic iron in Lapland, at Philipstad in Sweden, Arendal, &c. Very fine varieties at Campo longo, St Gotthardt, and in other parts of the Alps; in the Pyrenees, Silesia, Siberia, North America, and in many parts of Scotland, as in the limestone of Glen Tilt.

2. *Actinolite, Actinote* or *Strahlstein;* colour green, inclining either to black, or to grey, yellow, or brown. Translucent, or only on the edges. In imbedded long prismatic crystals ∞P. (∞P∞), or radiated columnar masses. B.B. melts to a greenish or blackish enamel: Analyses 6, 7 above. Occurs in talc, chlorite, and mica slates, also in gneiss, euphotide, and serpentine; and alone or with other silicates often forms subordinate beds in the crystalline rocks; but is

rather rare in veins. Fine varieties are found in Sweden and the Tyrol; also in Siberia, Finnland, Greenland, and North America. G. Rose found that actinolite from the Zillerthal when melted, assumed on cooling, the form of augite; and Mitscherlich observed this also of tremolite. It has hence been asserted that hornblende and augite differ only in the mode of cooling; but it should first be shown that no chemical change or decomposition occurred, and that the whole hornblende substance reappeared in the form of augite.

3. *Asbestus*, *Amianthus*, and *Byssolite;* fine fibrous varieties chiefly of tremolite and actinolite, of white, grey, or green colours. The fibres, often easily separable, elastic, and flexible, have been converted into incombustible cloth; and in 1727, some copies of a dissertation on this mineral by Brückmann were printed at Brunswick on paper prepared from it. In rock-cork, the fibres are interwoven into a loose felt-like texture, so light as to swim on water, and sectile like common cork; in mountain leather they form flat, flexible pieces; and in rock-wood they occur in long parallel curved masses, with a closer texture. Asbestus is common in Savoy, the Tyrol, and in Corsica, in such profusion, that Dolomieu used it for packing his other specimens. Rock-cork is met with in Saxony and Sweden; at Portsoy and Leadhills in Scotland; and in a recent marl formation with meerschaum at Vallecas, near Madrid; rock-leather chiefly at Leadhills and Strontian; and rock-wood near Sterzing in the Tyrol, with galena and zinc. Asbestus, however, is rather the name of a particular condition of several minerals,—as augite,—than a mere variety of hornblende; and chemical analysis can often alone decide to what species it belongs. Nos. 8, 9, 10, 11 are this variety, the latter named Kymatine by Breithaupt. Below are analyses of rock-wood (No. 1), mountain-leather (No. 2), mountain-cork (No. 3), mountain-wood (No. 4), of a peculiar character, and the xylite of Hermann (No. 5), of which only one specimen, supposed from the Ural, is known.

	Silica.	Magnesia.	Lime.	Alumina.	Iron protox.	Mang. prot.	Watr.	Total.	
1	54·92	26·08	...	1·64	12·60	...	5·28	100·52	Thomson, Tyrol.
2	57·65	2·06	10·00	9·50	5·80	...	21·70	106·71	Do. Strontian.
3	57·75	10·85	14·05	1·95	18·90	1·85	...	105·35	Do. Piedmont.
4	55·55	14·96	0·11	0·04	19·50*a*	...	10·31	99·97	Thaulow, Sterzing, (m. of 2.)
5	44·97	5·53	6·71	...	38·61*a*	...	4·18	100·10	Herman, Ural?

(*a*) Peroxide.

4. *Anthophyllite;* clove-brown, translucent, in radiating coarse columnar aggregates. B.B. very difficultly fusible. In it the lime is

chiefly replaced by protoxide of iron. First found in a bed with common hornblende, tremolite, and mica, in mica slate at Kongsberg, Norway, since at Brakka near Brevig in gneiss, and in the United States. Nos. 12 and 13 are analyses of this variety; Nos. 9, 10 of asbestus similar in composition.

5. *Hornblende*, of green or black, seldomer brown or grey colours; G. = 3·3 — 4. B.B. fuses rather easily to a yellow, greenish, or black enamel or glass. Three varieties are distinguished. (*a*) The noble or *Pargasite*, of a pale celadine or olive-green colour, and with a strong pearly or vitreous lustre. (*b*) Common hornblende, dark-leek or blackish-green, opaque, crystallised in druses, massive, or disseminated as a constituent of many rocks. Streak greenish-grey. Analyses Nos. 16–23. (*c*) Basaltic, velvet-black, foliated, opaque, streak grey or brown. Analyses Nos. 14, 15, 24, and 25.

Hornblende is very liable to decomposition. The mineral is first covered with a rusty crust, and finally falls down into a brown ferruginous earth. In this process the protoxide of iron is changed into the hydrated peroxide, and the magnesia and lime are partially removed. (Compare anal. No. 14 of the fresh with No. 15 of the decomposed mineral.) This tendency to decomposition confers great fertility on the soils resting on rocks containing this mineral. Hornblende is sometimes converted into a kind of steatite, the change in a specimen of pargasite mentioned by Blum having begun at the centre. In the Wolfsberg near Cernosin, Bohemia, it seems changed into a red jasper. The Uralit in which common hornblende assumes the form of augite will be noticed below.

This mineral is an important constituent of many rocks; the common variety forming almost the entire mass of the granular hornblende rock and hornblende slate. With common felspar it composes syenite, and with albite the diorite or greenstone. It occurs more incidentally in granite, gneiss, mica slate, chlorite slate, euphotide, and hypersthene rock. It is also common in granular limestone, and in beds with magnetic iron, with copper, iron, and cobalt pyrites, and with other ores. Noble hornblende is rare, and chiefly met with in crystalline limestone. Basaltic hornblende again chiefly in volcanic rocks, as basalt, leucite-porphyry, and trachyte. Distinct crystals of this mineral are rather rare, but occur in the Ural, at Arendal, and several places in Bohemia. Norway exhibits large masses of hornblende rock; hornblende slate forms many portions of the Alps; and both are common in the Scottish Highlands, where, however, hornblende has not always been distinguished from augite. It is regarded as a useful addition to the magnetic iron ores in smelting, unless united with the sulphuret of iron, when it renders the metal brittle.

Arfvedsonite of Brooke is also probably a variety of hornblende. Colour pure black; opaque; streak greyish-green. Cleavage very perfect along the faces of a prism of 123° 55′. G. = 3·44; H. = 6. Fusible in fine splinters in the flame of a candle. B.B. intumesces much, and melts to a black magnetic globule. Not soluble in acids. Chem. com. similar to hornblende, but specially 3 $\dot{F}e^5\ \ddot{S}i^6 + \dot{N}a^5\ \ddot{S}i^6$, part of the soda being replaced by lime, part of the silica by alumina. Analyses Nos. 27, 28. It occurs in crystalline schists at Kangerdluorsuk, Greenland; also in the zircon syenitè of southern Norway, and with magnetic iron at Arendal. The Ægirin from Brevig, Norway (No. 29), seems to be this variety.

The *Raphelite* of Thomson, from Perth, in Upper Canada, occurring in groups of delicate acicular crystals, translucent, vitreous, or resinous, and of a white or bluish-green colour, is, according to Dana, allied to arfvedsonite or an impure variety mixed with felspar. H. = 3·5; G. = 2·85. B.B. becomes white, opaque, and fuses on the edges.

Breislackite of Brocchi, fine capillary woolly crystals of a yellowish, reddish, or chestnut-brown colour, found in the lava of Capo di Bove near Rome and Vesuvius, is also a variety of hornblende. Its composition is not well known, but it is said to contain copper, yielding with salt of phosphorus a green globule, which becomes red in the reducing flame.

The *Uralite* of G. Rose is a dark-green or greenish-black mineral, with the outward form of augite, the internal structure and composition of hornblende. It was first observed in the augite porphyry of the Ural, but since in the augite rocks of the Veltlin, of the East and West Indies, of America, and in great variety at Arendal. In some specimens, the whole mass is Uralite, in others a small kernel of light-green vitreous augite remains; in a third there is a mere coating of the hornblende substance. Sometimes the two are irregularly combined, at other times regularly with their cleavage planes in one zone. Those of the uralite appear fibrous or striated parallel to their edges. G. Rose thinks this mineral a pseudomorph of hornblende after augite; others rather incline to regard it as an intimate intermixture of the two minerals in indefinite proportions, and so that where the hornblende predominates it gives the character to the cleavage, the augite being only seen in the fibrous aspect of the planes. A variety from Lake Baltym contained 53·05 silica, 12·90 magnesia, 12·47 lime, 16·37 iron protoxide, 4·56 alumina, (= 99·35) (Kudernatsch), which is not unlike the hornblende from Nordmark, No. 21 above.

101. AUGITE, *Werner, Phillips;* Pyroxene, *Hauy;* Paratomous Augite-spar, *Mohs.*

Monoclinohedric; C. = 74°, ∞P 87° 6′, P 120° 39′, —P 131° 29′, 2P 96° 36′; some of the more common combinations are ∞P (*m*) . ∞P∞ (*r*) . (∞P∞) (*l*) . P (*s*) . (fig. 130) ∞P. 2P. 0P3P. . ∞P∞, and

Fig. 130.

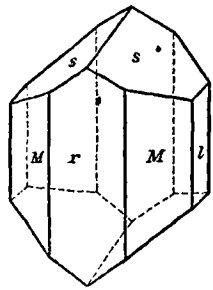
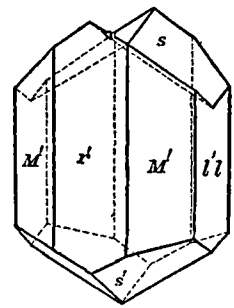


Fig. 131.



∞P∞ . (∞P∞) . P∞ . ∞P. The crystals are almost always prismatic, imbedded, or attached, and then generally united in druses. Common also in granular, columnar, and scaly aggregates. Macles (fig. 131) are common, formed according to various laws, but most frequently united by a face of the orthopinakoid, and with the chief axis the twin-axis. Cleavage, prismatic along ∞P generally rather imperfect, sometimes perfect; macrodiagonal and brachydiagonal imperfect. H. = 5 — 6; G. = 3·2 — 3·5. Pellucid in all degrees. Lustre vitreous, in some varieties pearly on ∞P∞. Colourless, and occasionally white, but usually coloured, grey, green, or black. B.B. generally fusible; imperfectly soluble in acids. Chem. com. generally $\dot{C}a\,\ddot{S}i + \dot{R}\,\ddot{S}i$, where $\dot{R}$ is essentially magnesia and protoxide of iron. Many may be represented by the formula $3\dot{C}a\,\ddot{S}i + 2\dot{M}g\,\ddot{S}i + \dot{F}e\,\ddot{S}i$; and the augites without alumina form three divisions, according to the relative prevalence of the latter two bases. Their ideal composition would be as follows:—

	Silica.	Lime.	Magnesia.	Iron.
a. Magnesia-augite,.....	56·36	25·46	18·18	...
b. Magnesia-iron-augite,	52·72	23·81	8·50	14·97
c. Iron-augite, ...	49·52	22·37	...	28·11

The very dark-green and black augites also contain about 7 per cent. alumina, which, as in hornblende, may either replace a portion of the silica, or form a peculiar compound mixed with the preponderating silicates. Analyses, next page.

	Silica.	Lime.	Magnesia.	Iron prot.	Mang. prot.	Alumina.	Total.	
1	54·15	24·74	18·22	2·51	0·18	0·20	100·00	Wackenroder, Fassathal.
2	54·83	24·76	18·55	0·99	0·32*a*	0·28	99·73	Bonsdorff, Tammare Finnland.
3	54·64	24·94	18·00	1·08	2·00*a*	...	100·66	H. Rose, Orrijerfvi Finnland.
4	57·40	23·10	16·74	'0·20	...	0·43	97·87	Trolle-Wachtmeister, Tjötten Norway.
5	53·97	25·60	17·86	2·00	0·57	...	100	Hermann, Achmatowsk.
6	57·26	23·66	13·23	1·66	1·73	2·33*c*	99·85	v. Kobell, Jenbach Tyrol.
7	54·66	23·57	16·49	4·44	0·42*a*	0·21	99 99	H. Rose, Sala Sweden.
8	54·08	23·47	11·49	10·02	0·61*a*	...	99·67	Do. Dalecarlia.
9	54·55	20·21	16·25	▶14	0·73*a*	0·14	99·02	Do. Do.
10	50·39	19·33	6·43	20·40	tracea	1·83	98·77	Seybert, Lake Champlain, N. A.
11	50·00	20·00	4·50	18·85	3·00	...*b*	97·25	Berzelius, Degerœ Finnland.
12	53·56	23·36	16·27	4·48	1·07	0·25	100·29	Reutersköld, Lanbanshytta.
13	52·18	22·00	7·06	16·13	1·61	1·42	99·40	G. Funk, Nordmark.
14	51·80	19·07	12·01	6·92	...	6·56*c*	97·38	Nordenskiöld, Pargas.
15	50·42	18·78	16·32	7·40	...	6·58	99·50	Kudernatsch, Rhön (m. of 2).
16	49·79	22·54	12·12	8·02	...	6·67	99·14	Do. Gillenfelder Maar Eifel.
17	47·05	23·77	15·35	7·57	...	5·16	98·90	Do. Do. Do.
18	50·12	20·05	13·70	11·60	...	4·21	99·68	Do. Zigolonberg Fassathal (m. of 2).
19	50·55	22·29	13·01	7·96	...	4·85	98·66	Do. Aetna.
20	50·90	22·96	14·43	6·25	...	5·37	99·91	Do. Vesuvius.
21	47·78	22·95	...	27·01	...	...	97·74	Wolff, Arendal.
22	49·01	20·87	2·98*d*	26·08	...	...	98·04	H. Rose, Tunaberg Sweden.
23	56·0	15·1	...	8·9	13·5	2·0*f*	97·5	Keating, New Jersey.
24	44·50	22·15	4 00	12·30	...	14·55*g*	99·35	Thomson, Do.
25	55·87	17·76	20·33	4·31	1·12	...	99·39	Meitzendorf, Schwarzenstein Tyrol.

(*a*) Peroxide; (*b*) + 0·90 loss by heat; (*c*) + 1·02 water; (*d*) with manganese; (*e*) + trace of potash; (*f*) + 1·0 oxide of zinc, and 1·0 loss by heat; (*g*) + 1·85 moisture.

Several varieties or sub-species of augite are distinguished by mineralogists, the more important being :—

1. *Diopside*, greyish or greenish-white, to pearl-grey or leek-green; streak white. Crystallized or in broad-columnar, or concentric lamellar aggregates. Transparent to translucent on the edges. Not affected by acids; B.B. fuses to a whitish semitransparent glass. Analyses Nos. 1–5. Occurs in beautiful crystals in the Mussa Alpe in Piedmont, and at Swartzenstein in the Tyrol with garnets and chlorite. It is abundant in the Alps, in Scandinavia, Finnland, the Ural with garnet in chlorite slate, at Bolton in Massachusetts in granular limestone, and in other parts of North America. G. Rose found that diopside fused in a porcelain crucible resumed its peculiar structure on cooling. Berthier and Mitscherlich have also produced a similarly crystallized body by fusing silica, lime, and magnesia in due proportion. Analysis No. 6 is a furnace-slag of similar composition, occurring in thin tabular crystals of a greenish colour, with distinct cleavage.

2. *Sahlite*, *Malacolite*, colour various shades of green, rarely yellow, brown, or red. Streak white; translucent, or only on the edges. Vitreous, inclining to pearly. Seldom crystallized (*Baikalite*), mostly columnar or lamellar. B.B. melts to a dark-coloured glass. Analyses Nos. 7–13. Fine sharp crystals of high lustre and dark or pistaccio-green colour occur in the Fassathal (*Fassaite*), the Brosso valley in Piemont, near Arendal, at Philipstadt in Sweden, in the

vicinity of Lake Baikal (*Baikalite*), and at Monroe in New York. *Sahlite* is found more often in beds than in veins, as of copper or iron pyrites, magnetic and other iron ores in many parts of Sweden; and with galena at Sahla. Also in granular limestone in Sweden, Scotland, Tyrol, and North America. It is thought useful as a flux in reducing ores, especially of iron. The *coccolite* is merely a distinct granular sahlite or augite.

3. *Augite* is leek-green or blackish-green, greenish-black, pitch or velvet-black; rarely brown. Streak greenish-grey. Lustre vitreous to resinous. Translucent or opaque. The crystals are usually imbedded, but sometimes found loose in volcanic ashes or sand, and then often appear as if semi-fused. Only slightly affected by acids. B.B. fuses to a black, often magnetic glass.

This is the most common form of this mineral. It is an essential component of many wide-spread rocks, as of basalt, dolerite, clinkstone, and augite porphyry. Sometimes it appears in single distinct, imbedded crystals, as at Boreslan in the Mittelgebirge, the Wolfsberg near Cernosin, in the Rhön and Vogelsgebirge, the Kaiserstuhl, in Auvergne, on Vesuvius, and in many parts of Scotland. In rocks it is associated chiefly with labradorite, and also with olivine, leucite, or nepheline, whilst quartz rarely, if ever, forms a constituent of the mass. It occurs in a similar manner in blocks ejected from volcanoes, and in some meteoric stones. In primary formations it is most common in granular limestone, either in crystals or grains, often apparently fused. It occurs thus in great beauty at Pargas in Finnland, and in many localities in North America. It is also found in beds of magnetic iron, as at Arendal, either mixed with the ore, or massive and united with calc spar in distinct veins. In such cases it acts beneficially on the production of the metal. Augite, or a substance similar in composition and form, has been found in the slag of furnaces; and Berthier, by fusing silica, lime, and magnesia in the proper proportions, and allowing them to cool very slowly, obtained a similar crystallized mass.

4. *Hedenbergite*, black or blackish-green, opaque or translucent on the edges. B.B. melts to a black magnetic glass. Seems to be a lime-iron augite, but its composition still rather uncertain. (Nos. 21, 22 anal.) Occurs with calc-spar in the mines of Tunaberg. The *Jeffersonite*, from Sparta, New Jersey, seems related, but neither its form nor composition (comp. anal. 23, 24) well ascertained. It is dark olive to black or brown, with resinous or imperfect metallic lustre.

5. *Amianthus*, some asbestiform minerals are probably augite (No. 25), but, as stated above, the greater number are rather hornblende.

Augite seems liable to various processes of decomposition, neither the causes nor mode of which are well understood. A common change is decomposition through the action of air and water, the augite and the rocks of which it forms the chief part, gradually acquiring a rusty colour, from the formation of a hydrous peroxide of iron, and at length falling down into earth or clay. In other cases it is changed into green earth, various stages in the process being often visible, as in an augite porphyry in the Pozza mountains in Tyrol, whilst the form of the crystals remains. Rammelsberg has made various researches on this subject, and gives the following analyses.

	Silica.	Alumina.	Iron protx.	Iron perx.	Lime.	Magnesia.	Alkali.	Watr.	Total.
1	45·87	11·16	24·63	...	1·50	0·28	6·72	9·82	100
2	39·48	10·31	15·66	8·94	15·24*a*	1·70	8.67		100
3	60·63	23·09	...	4·21	1·23	0·91	..	9·12	99·24
4	85·34	1·58	...	1·67	2·66	1·70	...	5·47	98·42

(*a*) Carbonate of lime.

Nos. 1 and 2 are green pseudomorphs, after augite, from the Fassa valley. Their composition, especially the amount of alkali, is very remarkable. No. 3 is from a basalt vein in gneiss, near Bilin, where crystals of considerable size are changed into yellow, brown, or greenish-clayey masses, with a specific gravity of 2·216, and a composition like that of cimolite, the bases of the augite being almost entirely removed along with a portion of the silica. In many places, as in the Fassathal, the Breisgau, &c., a variety of steatite has been formed, the lime and protoxide of iron being removed, and the proportion of magnesia consequently increased, water being also added. In the vicinity of volcanos, as Vesuvius, the augite is often altered, probably from the action of acids, which have removed the bases and most of the alumina (No. 4). In this process, the original black colour of the crystal first changes to greenish or bluish-grey, then to yellowish-white, which gradually encroaches on the dark kernel till the whole is converted into a white mass, porous and cellular within, but, as is common in similar pseudomorphs, firm and connected on the exterior.

The relation between hornblende and augite, or rather between the two classes of mineral substances of which they are types, is highly interesting. The preceding descriptions show how near their chemical composition and crystallization approach, and even the variations in these points and external aspect correspond, or form parallel series. The faces of the crystals are either inclined to each other at

angles that nearly agree, or if some forms occur in augite which have not been observed in hornblende, yet their occurrence is mathematically possible according to the laws of crystallography. Hence it has sometimes been proposed to unite these minerals in one species. The investigations of Gustav Rose, however, prove that, notwithstanding the similarity of hornblende and augite, they still differ too widely to justify their union. Thus, the former contains more silica, and Bonsdorff has found in it ½ to 1 per cent. of fluoric acid, which does not appear in the latter. Hornblende, too, is more fusible than augite, and ranges lower in specific gravity (hornblende from 2·931 to 3·445; augite 3·195—3·525). Though both possess a cleavage parallel to their vertical prisms, yet these differ in angular dimensions, and both are never observed in the same individual. The cases in which G. Rose once thought that this occurred, he now believes were not simple crystals, but unions (*Verwachsungen*) of hornblende and augite crystals, each with its own cleavage. These minerals also occur in distinct geognostic positions. Hornblende in rocks containing quartz or free silica, and mostly with minerals that are neutral compounds of silica, as orthoclase and albite; augite in rocks that do not contain free silica, and mostly with minerals that are not neutral silicates, as labradorite, olivine, and leucite. Hence there are two distinct series of massive or igneous rocks; the hornblende series, including granite, syenite, diorite, diorite porphyry, and red porphyry; and the augite series or hypersthene rock, gabbro, dolerite, nepheline rock, augite porphyry, and leucite porphyry. In some rare instances, these two minerals have been found together, either regularly conjoined or in distinct conditions. Thus, in the lava of Vesuvius, the basis contains imbedded crystals of augite and leucite, whilst fine acicular crystals of hornblende line the walls of drusy cavities, but never form part of the basis. The occurrence of hornblende with augite or olivine in some basalts or trachytes, requires further investigation. The Uralite, with the external form of augite, the internal structure of hornblende, is considered by Rose as a pseudomorphic formation,—augite changing into hornblende. It has been necessary to give these details, as in several recent mineralogical works the authority of G. Rose is adduced against the opinions he has so very ably supported. (Vide Rose, Reise nach dem Ural, Vol. ii. pp. 347—378.)

102. HYPERSTHENE, *Hauy*, *Phillips*, *&c.*; Paulite, *Werner*; Prismatoidal Schiller-spar, *Mohs*.

Isomorphous with augite? ∞P 87°. Massive, in crystalline and granular aggregates, or disseminated. Cleavage, brachydiagonal very perfect, prismatic along ∞P distinct, macrodiagonal very imperfect;

H. = 6; G. 3·3 — 3·4. Opaque or translucent on thin edges. Lustre vitreous, inclining to resinous; but metallic pearly on the principal cleavage planes. Colour pinchbeck-brown inclining to copper-red, pitch-black, and greyish-black. Streak greenish-grey. Not affected by acids. B.B. melts more or less easily to a greenish-black glass, often magnetic. Chem. com. analogous to augite, or generally $(\dot{M}g, \dot{F}e)\ \ddot{S}i$. Analyses.

	Silica.	Alumina.	Magnesia.	Lime.	Iron protox.	Mang. prot.	Watr.	Total.	
1	54·25	2·25	14·00	1·50	24·50*a*	trace	1·00	97·50	Klaproth, Labrador.
2	46·11	4·07	25·87	5·38	12·76	5·29	0·48	98·90	Muir, Paul's Island.
3	51·35	...	11·09	1·84	33·92	...	0·50	98·70	Do. Skye.
4	53·27	2·00	18·06	...	14·43	6·34	...	99·09	Do. Baffin's Bay.
5	51·36	0·37	21·31	3·09	21·27	1·32	...	98·72	Damour, Labrador.
6	52·17	4·00	11·33	20·00	10·73	...	1·00	99·23	Seybert, Wilmington Pa.
7	45·45	...	18·00	24·33	11·49*a*	...	...	99·27	Beck, Lake George N. Y.

(*a*) Peroxide.

Hypersthene differs chemically from augite in the small amount of lime. It forms a constituent of several rocks, as with labradorite of hypersthene rock; and with labradorite and chlorite of diabase. It also occurs in the euphotide or gabbro. The finest specimens come from Paul's Island, the adjoining coast of Labrador, and Greenland. Hypersthene rock is common in many parts of Norway, at Elfdal in Sweden, where it is polished as an ornamental stone, in Skye in Scotland, and in Cornwall. It is less abundant in the Harz, the Thuringerwald, the Fichtelgebirge, and other parts of Germany. The American varieties Nos. 6, 7, are anomalous from the amount of lime, and perhaps only augite.

103. BRONZITE, *Karsten*, *Phillips;* Diallage, *Hauy;* Hemiprismatic Schiller-spar, *Mohs* (in part.)

Monoclinohedric, similar to augite; C. = 72°, ∞P 86° (only approximations, *Mohs.*) Occurs in indistinct imbedded crystals, or in granular aggregates. Cleavage, orthodiagonal very perfect; prismatic along ∞P imperfect; clinodiagonal in traces. H. = 1·5 — 5, G. 3·2 — 3·5. Translucent, or only on the edges. Lustre resinous or vitreous; on the more perfect cleavage planes, which are often slightly curved and fibrous, metallic-pearly or silky. Clove-brown to pinchbeck-brown, sometimes greenish or yellowish. Streak white. Not affected by acids. B.B. very difficultly fusible to a dark-brown or blackish-green glass. Chem. com. $(7\ \dot{M}g + \dot{F}e)\ \ddot{S}i = 58·6$ silica, 33·0 magnesia, and 8·4 iron protoxide. Analyses, next page.

	Silica.	Alumina.	Magnesia.	Lime.	Iron protox.	Mangan. protox.	Watr.	Total.	
1	57·19	0·70	32·67	1·30	7·46	0·35	0·63	100·30	Köhler, Stempel.
2	56·84	2·07	29·68	2·20	8·46	0·62	0·22	100·06	Do. Ultenthal, Tyrol.
3	55·84	1·09	30·37	...	10·78	...	1·80	99·88	Regnault, Do.
4	56·41	...	31·50	...	6·56	3·30	2·38	100·15	Do. Gulsen, Styria.
5	58·00	1·33	29·66	...	10·14	1·00	...	100·13	v. Kobell, Greenland.

Occurs in serpentine near Kraubat in Styria, and in Baireuth; in basalt (with olivine, No. 1) near Marburg, and near Sontra, in Hessia. No. 5, from Ujardlersoat, in Greenland, was considered anthophyllite. It is distinguished from diallage and schiller-spar by its action before the blowpipe, and from the latter also by its greater hardness and specific gravity.

104. DIALLAGE, *v. Kobell, Hauy;* Prismatic Schiller-spar, *Mohs*, (in part.)

Cleavage very perfect in one direction, imperfect in a second, and traces only in others. H. = 4; G. = 3·2—3·3. Translucent in thin plates. Lustre resinous or vitreous, but metallic-pearly, or silky on the cleavage planes. Colour light-grey, brownish-grey, or pinchbeck-brown. Streak white. Not affected by acids. B.B. melts rather easily to a greyish or greenish enamel. Chem. com. ($3\dot{C}a + \dot{M}g + \dot{F}e$) $\ddot{S}i$, with 54·6 silica (with alumina), 21·2 lime, 15·1 magnesia, and 9·1 iron protoxide. Analyses.

	Silica.	Alumina.	Magnesia.	Lime.	Iron protox.	Mangan protox.	Watr.	Total.	
1	52·89	2·70	17·68	17·40	8·41		1·06	100·14	Köhler, Baste,* (m of 2.)
2	51·34	4·39	15·69	18·28	8·23		2·11	100·04	Do. Salzburg.
3	53·20	2·47	14·91	19·09	8·67	0·38	1·77	100·49	Do. Prato, Florence.
4	51·25	3·98	22·88	11·18	6·75	...	3·32	99·36	Regnault, Traunstein.†
5	50·05	2·58	17·24	15·63	11·98	...	2·13	99·61	Do. Piemont.
6	52·60	3·27	16·43	20·44	5·35	...	1·59	99·68	Do. Ural.
7	50·20	3·80	16·40	20·26	8·40	trace.	...	99·06	v. Kobell, Grossarl.†
8	49·50	5·55	14·12	18·12	3·28	...	1·77*a*	99·74	Schaffhäutl, Braceo, Genua.
9	53·74	1·34	25·09	4·73	11·51	0·23	3·76	100·40	Kohler, Baste.

(*a*) + 3·65 protoxide of vanadium, and 3·75 soda.

* Near Harzeburg in Harz. † In Salzburg.

Haidinger has shown that the Smaragdite of Saussure and many other so-called diallages are merely a peculiar form of augite or hornblende, or a combination of these minerals, with the orthopinakoid as the chief plane of union and cleavage. This laminar aggregate is so important as a constituent of the euphotide, that it should perhaps retain the name of diallage, which v. Kobell appropriates to the

more calcareous and easily fusible varieties included in the old species, the others being separated as Bronzite.

Besides the above, diallage occurs in many other localities in the Harz, Silesia, the Alps, Apennines, and Ural, especially in serpentine, or in the crystalline limestone near it.

The *Vanadine-bronzite* of Schaffhäutl (No. 8) differs from diallage chiefly in containing soda and vanadic acid. It is coarse foliated, with pearly lustre on the curved cleavage planes, of a greenish-grey colour, and translucent in thin plates. G. = 3·255. B.B. fuses to a brown globule. The *Diaclasite* of Hausmann (No. 9) seems merely a magnesian diallage. It is pale or brass-yellow, inclining to green or silver-white; and is found in euphotide in the Harz, and in gneiss in the Guadarrama mountains in Spain.

105. RHODONITE, *Beudant;* Manganese-spar, *Werner;* Siliciferous oxide of manganese, *Phillips;* Diatomous Augite-spar, *Mohs.*

Monoclinohedric? massive and distinctly crystalline, or granular and compact. Cleavage, prismatic along ∞P 87° 5′ imperfect, along (∞P∞) perfect, also along ∞P∞. Brittle; H. = 5 — 5·5; G. = 3·5 — 3·6. Translucent; vitreous or partly pearly; colour dark rose-red, bluish-red, or reddish-brown. Not affected by acids. B.B. fusible in the red. flame to a red glass, in the ox. flame to a black metallic globule. With borax shows reaction for manganese. Chem. com. $\dot{Mn}\,\ddot{Si}$ = 45·33 silica, and 53·67 manganese protoxide, but the latter partly replaced by lime. Analyses.

	Silica.	Mang. protox.	Lime.	Iron prot.	Magnesia.	Total.	
1	48·00	49·04	3·12	...	0·22	100·38	Berzelius, Langbanshytta.
2	45·49	39·46	4·66	6·42	2·60	98 63	Ebelmen, Algiers.
3	46·37	47·38	5·48	...	...	99·23	Do. St Marcel, Piemont.
4	48·90	36·06	14·57	0·91	...	100 34	Dumas, the Bustamite.
5	44·45	26·96	14·43	1·15	0·64*a*	99·90	Ebelmen, Tetala, Mexico.

(*a*) + 12·27 carbonate of lime.

Rhodonite occurs in iron ore in dolomite in gneiss in Sweden, and in clay slate with quarz near Katharinenburg in Siberia. Also in the Harz, Siebenburg, in New Jersey, and other parts of North America. The Bustamite (Nos. 4, 5) is a very calcareous variety from Mexico. It has a radiating columnar texture, and a pale-greenish or reddish-grey colour. G. = 3·1 — 3·3. Chem. com. 2 $\dot{Mn}\,\ddot{Si}$ + $\dot{Ca}\,\ddot{Si}$.

The *Black Silicate of manganese*, or *Hydrosilicate* of Phillips, is amorphous and soft; of an iron-black colour, semi-metallic lustre, and yellowish-brown streak. B.B. intumesces and melts in red. flame to a green, in ox. flame to a black glass. In the closed tube yields

water and becomes grey. Klaproth found 25 silica, 13 water, and 60 proto-peroxide of manganese. Found formerly in the Klapperud iron mines Dalecarlia.

The *Fowlerite* of Shepard from Franklin in New Jersey occurs in large monoclinohedric crystals; C. = 72°, ∞P 86½°. Cleavage, distinct along ∞P. The crystals are dull, reddish-brown, G. = 3.4, and scratch with the knife. Thomson found in them 29·5 silica, 50·6 manganese protoxide, 13·2 iron peroxide, and 3·2 water, (= 96·5). It is perhaps a variety of Rhodonite.

Various compact, reddish brown, or grey coloured mixtures of Rhodonite or other silicates of manganese protoxide with hornstone, chiefly from the Harz, have been described as distinct species, under the names of Hydrophite, Photicite, Allagite, and Hornmanganese, but have no title to a place in the system.

106. Tephroite, *Breithaupt*; *Mohs*; Anhydrous Silicate of Manganese, *Thomson*.

Tetragonal; in distinct crystalline and granular masses. Cleavage, prismatic along ∞P rather perfect, pyramidal in traces. Fracture conchoidal, uneven and splintery. H. = 5·5; G. = 4·0 — 4·2. Translucent on the edges; lustre resinous adamantine. Ash-grey, with reddish-brown or black tarnish. B.B. fuses very easily to a black or dark-brown slag; with borax shows reaction for iron and manganese. Soluble and gelatinizes in hydrochloric acid. Chem. com. $\dot{Mn}^2\,\ddot{S}i$ = 30 silica and 70 manganese protoxide. Analyses.

	Silica.	Mang. protox.	Iron protox.	Mag. Lime.	Water.	Total.	
1	29·64	66·60	0·92	...	2·70	99·86	Thomson, Franklin.
2	28·66	68·88	2·92	traces.	...	100·46	Rammelsberg, Do.

Found at Franklin and Sparta in New Jersey.

107. Troostite, *Shepard*, *Mohs*; Ferruginous Silicate of Manganese, *Thomson*.

Rhombohedric; in the combination ∞P2. R. with R 115° (or 124° Thomson). Also massive and granular. Cleavage, prismatic along ∞P2 perfect, basal and rhombohedric along R imperfect; brittle. H. = 5·5; G. = 4·0 — 4·1. Transparent to opaque. Lustre vitreous, inclining to resinous. Asparagus-green, also yellow, grey, and reddish-brown. B.B. fuses on the edges; with borax forms a violet-blue glass. Decomposed by nitric acid. Thomson found in it 30·65 silica, 46·22 manganese protoxide, 15·45 iron peroxide, and 7·30 water and carbonic acid, (= 99·62). Berzelius, assuming the iron to

be the protoxide, makes it 3 $\dot{M}n^3$ $\ddot{S}i$ + 2 $\dot{F}e$ $\ddot{S}i$, mixed with some carbonate of manganese protoxide. Found at Sterling in New Jersey.

The last two silicates of manganese might be classed in the family of metallic stones, or near to olivine.

108. WOLLASTONITE, *Hauy;* Tabular-spar, *Phillips;* Schaalstein, *Werner;* Tafelspath, *Stutz;* Prismatic Augite-spar, *Mohs.*

Monoclinohedric; $^{\circ}C = 84^{\circ}\ 40'$, $\infty P\ 140^{\circ}$, according to V. Kobell; lengthened along the orthodiagonal; very rarely freely crystallized, mostly in imperfectly-formed, broad prismatic or laminar masses. Cleavage, along 0P and $\infty P\infty$, or basal and orthodiagonal, perfect, but planes uneven or rough. H. = 5; G. = 2·7 — 2·9. Translucent. Lustre vitreous, and rather pearly on the cleavage-planes. Colourless or white, but generally inclining to grey, yellow, red, or brown. Streak white. Phosphoresces with heat or friction. Gelatinizes in hydrochloric acid. BB. difficultly fusible to a semitransparent glass. Chem. com. $\dot{C}a$ $\ddot{S}i$, with 52·5 silica, and 47·5 lime. Analyses.

	Silica.	Lime.	Magnesia.	Iron perox	Watr.	Total.	
1	53·1	45·1	1·8	....	....	100	Beudant, Cziklowa, Bannat.
2	51·60	46·41	...	trace.	... *a*	99·12	H. Rose, Perhoniemi, Finnland.
3	52·58	44·45	0·68	0·13	0·99	99·83	Bonnsdorff, Skräbböle, Do.
4	52·50	46·33	...	1·70	...	100·53	Hisinger, Karelen.
5	51·0	46·0	trace.	1·3	1·0	99·3	Seybert, Willsborough, N. York.
6	51·50	45·45	0·55	...	2·00	99·50	v. Kobell, Capo di Bove, Rome.
7	51·67	47·00	...	1·35	...	100·02	Vanuxem, Willsborough.
8	51·90	47·55	0·25	...	...	99·70	Beck, Diana, N. York.
9	50·60	47·21	...	0·14 *b*	...	97·95	Palander, Pargas.
10	50·72	43·80	0·88	0·85 *c*	... *d*	99·31	Weidling, Göckum, Upland.
11	54·00	30·79	2·59	trace.	5·43 *e*	98·36	Walker, Corstorphine Hills.
12	49·73	40·79	...	0·31 *d*	... *f*	98·65	Walchner, slag from furnace.

(*a*) + 1·11 mixture of asbestus; (*b*) with alumina; (*c*) protoxide; (*d*) + 0·33 manganese protoxide and 2·73 carbonate of lime; (*e*) + 5·55 soda and trace of alumina; (*f*) + 7·82 alumina.

Hauy described this mineral as rhombic, and Phillips as triclinohedric. Mr Brooke and v. Kobell have shown that the crystals from Capo di Bove are monoclinohedric like those of augite, thus corresponding to its chemical composition, which, as Frankenheim states, is an augite of the simplest kind.

Wollastonite occurs chiefly in granular limestone, as in the Bannat, Finnland, Sweden, North America, and Ceylon. Crystallised chiefly in lava at Capo di Bove, and in blocks ejected by Vesuvius. It is found also in clinkstone in the Castle rock at Edinburgh, along with prehnite. No. 11, a similar mineral from the greenstone of Corstorphine Hill, is probably a distinct species. It is white, fibrous, does not effervesce with acids, and B.B. fuses with intumescence to a hard

white enamel. Wollastonite has been formed chemically; and No. 12 is a similar substance from the slags of the iron furnaces at Oberweiler in Baden.

Dr Thomson gave the same name to a distinct mineral from Kilsyth.

110. ACHMITE, *Berzelius*, *Phillips*, *Beudant*, *&c.*; Paratomous Augite-spar, *Mohs*.

Monoclinohedric; isomorphous with augite. The crystals are long prisms formed by ∞P . ∞P∞ . (∞P∞), and terminating very acutely in 4P. Cleavage like augite, or prismatic along ∞P (87°), orthodiagonal and clinodiagonal; H. = 6 — 6·5; G. = 3·5 — 3·6 (3·43, in powder 3·53, Ram.). Nearly opaque; lustre vitreous; colour brownish or greenish-black, occasionally spotted. Streak greenish-grey. Imperfectly soluble in acids. B.B. fuses easily to a black magnetic glass. With borax shows reaction for iron, with soda on platina wire for manganese. Chem. com. $\dot{Fe}^2\,\dot{S}i^3 + 2\,\dot{N}a\,\dot{S}i^3$ = 55·6 silica, 32 iron peroxide, and 12·4 soda. Analyses.

	Silica.	Iron perox.	Mang. perox.	Soda.	Lime.	Magnesia.	Loss by heat.	Total.	
1	54·27	34·44*a*	...	9·74	...	...	1·88	100·33	Ström, Eger.
2	55·25	31·25	1·08	10·40	0·72	...	...	98·70	Berzelius, Do.
3	52·02	28·08*b*	3·49	13·33	0·88	0·50	0·68*c*	98·98	Lehunt, Do.
4	54·13	34·44	...	...	...	...	...	..	Rammelsberg, Do.

(*a*) With manganese peroxide; (*b*) protoxide; (*c*) alumina.

Rammelsberg found that achmite contains no protoxide of iron. Ström and Berzelius observed traces of titanic acid, von Kobell 3·25 per cent., and Rammelsberg 3·1 per cent., but mixed with silica, and probably from a mixture of titanic-iron (iserine).

Achmite occurs, though rarely, imbedded in quartz and felspar in granite at Eger, and also it is said in syenite at Kless near Porsgrund, in Norway.

111. SORDAWALITE, *Nordenskiöld*.

Massive. Fracture conchoidal; brittle; H. = 4 — 4·5. G. = 2·55 — 2·62. Opaque; resinous or vitreous. Brownish-black or blackish-green. Streak liver-brown. In closed tube gives water. B.B. fuses to a black globule; with borax and salt of phosphorus reaction for iron and silica. Chem. com. $\dot{A}l\,\dot{S}i^2 + 4\,\dot{R}\,\dot{S}i + 2\,\dot{H}$; the silica including the phosphoric acid, and $\dot{R}$ being equal parts of iron protoxide and magnesia. Nordenskiöld found 49·40 silica, 13·80 alumina, 18·17 iron protoxide, 10·67 magnesia, 2·68 phosphoric acid, 4·38 wa-

ter (= 99·10). Berzelius considers it a mixture of phosphate of magnesia, with a bisilicate. It occurs in thin veins on trap at Sordawala in Finnland.

112. KROKYDOLITE, *Hausmann, Phillips, Mohs;* Blue ironstone, *Klaproth.*

Microcrystalline, in plates of very fine, easily separable but tough, elastic fibres. H. = 4; G. = 3·2 — 3·3. Translucent; silky, or dull. Colour indigo blue; streak lavender blue. In closed tube yields water; in open tube becomes reddish-brown. B.B. fuses easily to a black magnetic glass. With salt of phosphorus shows reaction for iron, and leaves silica. Chem. com. 3 $\dot{F}e\,\ddot{S}i + \dot{R}\,\ddot{S}i^2 + 2\,\dot{H}$, where $\dot{R} = \frac{2}{3}\,\dot{N}a + \frac{1}{3}\,\dot{M}g$. Analyses.

	Silica.	Iron prot.	Mang. perox.	Magnesia.	Lime.	Soda.	Water.	Total.	
1	50·81	33·88	0·17	2·32	0·02	7·03	5·58	99 81	Stromeyer.
2	51·64	34·38	0·02	2·64	0·05	7·11	4·01	99·85	Do.

No. 1 is an asbestiform, No. 2 a fibrous variety, both from Orange river in South Africa. It also occurs in the zircon syenite of Stavern, Norway, and in Greenland. The fibrous Siderite, from the gypsum at Golling in Salzburg, seems also krokydolite. Berzelius points out its similarity in composition to achmite.

113. PYRALLOLITE, *Nordenskiöld, Phillips, &c.;* Tetartoprismatic Picrosmine-steatite, *Mohs.*

Triclinohedric; prismatic combination of $\infty'P'.P.\breve{\infty}P\infty$; with $\infty P'$ to $\infty'P = 94°\ 36'$; and $\infty\breve{P}\infty$ to $\infty P' = 130°\ 33'$, and to $\infty'P = 144°\ 3'$. Usually massive, columnar, or granular. Cleavage, right and left hemiprismatic, also macrodiagonal distinct. Fracture uneven, splintery; rather brittle. H. = 3·5 — 4; G. = 2·55 — 2·60. Opaque or translucent on the edges. Resinous, on the cleavage planes pearly. Greenish-white, asparagus-green, and yellowish-grey. In the closed tube gives out water; B.B. becomes black, then white, and fuses with much difficulty on thin edges to a white enamel. Chem. com. probably silicate of magnesia with a little silicate of lime and water. Nordenskiöld found in it 56·62 silica, 23·38 magnesia, 5·58 lime, 0·99 manganese protoxide, 0·09 iron peroxide, 3·38 alumina, 3·58 water, 6·38 bituminous matter and loss (= 100). Occurs in granular limestone with green augite at Storgard in Pargas, Finnland. Exposed to the light and air, it gradually becomes pale and dull.

114. PYRARGILLITE, *Nordenskiöld, Phillips, Mohs.*

Probably rhombic, but the crystals indistinct and imbedded. Also massive. Cleavage not observable. Fracture uneven. H. = 3·5; G. = 2·5. Translucent on the edges, or opaque. Dull resinous lustre. Greyish or blackish-blue, also liver-brown or brick-red. Soluble in hydrochloric acid. B.B. infusible alone, slowly with borax or salt of phosphorus. Chem. com. $2\,\ddot{A}i\,\ddot{S}i^2 + \dot{R}\ddot{S}i + 6\,\dot{H}$; or, by Nordenskiöld's analysis, 43·93 silica, 28·93 alumina, 5·30 iron protoxide, 2·90 magnesia with manganese, 1·05 potash, 1·85 soda, 15·47 water (= 94·43). Occurs at Helsingfors in Finnland in granite.

115. KARPHOLITE, *Werner, Hauy, Phillips, Mohs.*

Only found in radiating or stellated masses of fine acicular or short capillary crystals. H. = 5 — 5·5; G. = 2·935. Translucent, silky, and straw-yellow, inclining to wax-yellow. Streak colourless. In the closed tube yields water with traces of fluorine. B.B. intumesces and forms an opaque brown glass. With fluxes shows reaction for manganese. Scarcely affected by acids. Chem. com. $\ddot{A}i\,\ddot{S}i + \dot{M}n\,\ddot{S}i + 2\,\dot{H}$. Analyses.

	Silica.	Alumina.	Manganese perox.	Iron perox.	Lime.	Water.	Fluoric acid.	Total	
1	37·53	29·47	18·33	6·27	....	11·36	...	99·96	Steinmann.
2	36·15	28·67	19·16	2·29*a*	0·27	10·78	1·47	98·79	Stromeyer.

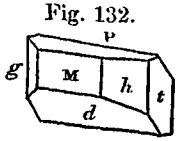
(*a*) Protoxide.

Only found at Schlakenwald in Bohemia, in a quartzose granite with fluor spar. The fluoric acid is perhaps accidental; or, according to Berzelius, combines with the silicate of manganese. In external aspect it resembles some of the zeolites, but differs in its action with acids.

116. BABINGTONITE, *Lévy, Phillips, &c.*; Axotomous Augite-spar, *Mohs.*

Triclinohedric; $\infty\bar{P}\infty\,(M) : \infty\breve{P}\infty\,(t) = 112°\ 30'$; $\infty P'(h) : \infty'P\,(g) = 90°\ 40'$; $0P\,(P) : \infty\bar{P}\infty = 92°\ 24'$, $0P : \infty\breve{P}\infty = 88°\ 0'$. These forms, with $\bar{P}\infty\,(d)$, combine in very low eight-sided prisms, terminating in two planes (fig. 132). Crystals small, attached. Cleavage, basal very perfect; brachydiagonal perfect. H. = 5—5·5; G. = 3·4—3·5 (3·355, Thomson). In thin laminæ, translucent, and greenish parallel to the chief axis, brownish at right angles to it. Lustre splendent vitreous. Colour black. Slowly soluble in boiling hydrochloric acid. B.B. fuses easily with

Fig. 132.



effervescence to a shining brownish-black magnetic bead; with borax to a yellow bead changing to violet. Chem. com. $\dot{C}a^2\,\ddot{S}i^3 + 2\,\dot{F}e\,\ddot{S}i$, with 54·7 silica, 20·3 lime, and 25·0 iron protoxide. Analyses.

	Silica.	Iron protox.	Lime.	Magnesia.	Mang. protox.	Alumina.	Loss by heat.	Total.	
1	54·4	21·3	19·6	2·2	1·8	0·3	0·9	100·5	Arppe, Arendal.
2	47·46	16·81	34·74	2·21	10·16	6·48	1·24	99·10	Thomson, Do.

Children found titanium, but it is a mere mixture of titanic iron, which may be separated by the magnet. Thomson's analysis agrees with Arppe's, when the alumina is conjoined with the silica, and the manganese with the iron protoxide. The composition of this mineral is, however, very peculiar. It occurs near Arendal in beds of magnetic iron ore; in Zetland in quartz; and on felspar at Governeur, New York.

117. Isopyre, *Haidinger*, *Phillips*, *Mohs*.

Amorphous. Brittle; fracture conchoidal. H. = 5·5 — 6; G. = 2·90 — 2·95. Semi-translucent or opaque. Vitreous. Greyish-black or velvet-black, sometimes with red spots. Streak pale greenish-grey. Slightly magnetic. Imperfectly soluble in acids. B.B. fuses to a magnetic globule. On platina wire colours the flame green. Chem. com. perhaps $(\ddot{A}l, \ddot{F}e)^2\,\ddot{S}i^3 + 3\,\dot{C}a\,\ddot{S}i$, or, by Turner's analysis of a specimen from Cornwall, 47·09 silica, 13·91 alumina, 15·43 lime, 20·07 iron peroxide, 1·94 copper oxide (= 98·44). But from the colour it is probable that part at least of the iron is the protoxide. Isopyre is found at St Just near Penzance, in pieces two inches in diameter, in a quartzose granite with turmaline and tin ore. Also in fissures in breccia on the Calton Hill, Edinburgh, with brown iron ore. The name refers to the slight change produced on its aspect by fusion.

118. Polylite, *Thomson*.

Occurs in plates with a lamellar structure, and cleavage in one direction. Brittle; H. = 6 — 6·5; G. = 3·231. Opaque, vitreous, and black. B.B. infusible alone, with borax forms a black glass. Thomson's analysis gave 40·04 silica, 34·08 iron protoxide, 11·54 lime, 6·60 manganese protoxide, 9·43 alumina, 0·40 water (= 102·09); or, according to v. Kobell, $(\dot{F}e, \dot{C}a, \dot{M}n^3)\,(\ddot{S}i, \ddot{A}l)^2$, which is nearly the composition of hedenbergite and some augites. Said to occur at Hoboken in New Jersey in magnetic iron ore, but the latter mineral is not known there.

119. Tachylite, *Breithaupt*, *Mohs*.

Amorphous; fracture conchoidal; H. = 6·5; G. = 2·52. Opaque; vitreous, or resinous. Velvet, brownish, or greenish-black. Streak dark-grey. B.B. fuses very easily to an opaque glass. With salt of phosphorus forms a glass, yellow and transparent when hot, opaque when cold, and in the reducing flame becomes pale violet-blue. Wholly soluble in hydrochloric acid. Analyses.

	Silica.	Titanic acid.	Alumina.	Iron prot.	Lime.	Magnesia.	Soda.	Potash.	Mang. protox.	Water & ammon.	Total.
1	50·22	1·41	17·84	10·27	8·25	3·37	5·18	3·87	0·40	0·50	101·31
2	55·74	...	12·40	13·06	...	5·92	3·88	0·60	0·19	2·73	99·80

No. 1 by C. Gmelin, of the variety from the igneous rocks of the Vogelsberg, gives nearly 2 Ṙ S̈i + Ä̈i S̈i, and is named Hyalomelan by Hausmann as a distinct species. No. 2, by Schnedermann is from the basalt of the Säsebühl near Dransfeld. It also occurs in basalt near Munden.

IX. Family.—Clays.

Note.—Though many of the substances included in this family have great economic importance, yet, generally, they have few claims to a place in a mineral system. They rarely form true species, and are mostly indefinite mixtures, or mere products of the decomposition of rocks and minerals.

120. Kaolin, Porcelain-earth.

Occurs massive, forming whole beds and veins. Fracture uneven; fine-earthy, very soft, sectile, and friable. H. = 1; G. = 2·2. Opaque, dull; colour various shades of white or grey, inclining to blue, green, yellow, or red. Feels meagre when dry, and plastic when wet. In the closed tube yields water. B.B. is infusible. Not affected by hydrochloric acid, but decomposed by warm sulphuric acid, which dissolves the alumina and leaves the silica. Chem. com. very variable, but approximates to Ä̈i S̈i^2 + 2 Ḣ, which gives 47·2 silica, 39·1 alumina, and 13·7 water. It seems chiefly a product of the decomposition of the orthoclase felspar, or of granite, porphyry, and other rocks containing this mineral. The substance washed out of the felspar, or K̇ S̈i^4, has been artificially prepared by Forchhammer. Analyses, next page.

	Silica.	Alumina.	Magnesia.	Potash.	Water.	Total.	
1	58·6	34·6	1·8	2·4	...	98·9	Berthier, Sedlitz, near Meissen.
2	46·46	36·37	1·47 *a*	...	13·61	99·13	Forchhammer, Do.
3	46·8	37·3	trace.	2·5	13·0	99·6	Berthier, St Yrieux, Limoges.
4	48·68	35·92	0·52 *b*	0·58 *c*	13·13	99·83	Forchhammer, Do.
5	40·15	36·20	1·75	9·50 *d*	11·65	99·25	Boase, Breage.
6	39·55	38·05	1·45	8·70 *d*	12·50	100·25	Do. St Stephen's, Cornwall.
7	47·20	38·80 *e*	0·24 *f*	1·76 *g*	12·00	100·00	Fownes, Dartmoor, Devon.

(*a*) Carbonate of lime, + 1·22 iron perox.; (*b*) with manganese; (*c*) with soda; (*d*) insoluble matter and talc; (*e*) with traces of iron and manganese; (*f*) lime; (*g*) alkali and loss.

Berthier, Forchhammer, Malaguti, and others, have furnished many more analyses. This substance occurs in the above and other localities, and is used in the manufacture of porcelain.

121. CLAY.

Clays are often merely varieties of kaolin, mixed with quartz-sand, carbonate of lime, magnesia, the oxyhydrates of iron and manganese, or other substances. Generally they are compact and friable, of white, yellow, red, blue, grey, or brown colours. Their spec. gr. varies from 1·8—2·7. Several varieties are distinguished, as:—*Pipe-clay*, of greyish or yellowish-white colours, with a greasy feel. It adheres strongly to the tongue; and when wet is very plastic and tenacious, and in the fire burns white. It occurs in great abundance in Devonshire, and in the Trough of Poole in Dorsetshire; in France at the Foret de Dreux; near Namur in Belgium; Coblentz, Cassel, and Fritzlar in Germany; and in the eocene formation at Martha's Vineyard in Massachusetts. It is used for manufacturing tobacco pipes and similar articles, and the more infusible varieties for crucibles and for lining furnaces.—*Potter's clay*, red, yellow, green, or blue, becoming yellow or red when burnt. It is more easily fused than the former, and often effervesces with acids. That used in the potteries in England comes chiefly from Devonshire. Yssel in Holland, Grossalmerode in Hessia, Steinberg near Munden, Deistee in Hanover, and near Brunswick, are other famous localities. The *Loam* of the English, *Lehm* or *Löss* of the Germans, is a coarser and more impure variety of clay, with more sand, and consequently less plastic. The Löss is common in the valley of the Rhine; a marly loam (*Lehmmergel*) in northern Germany. The *Letten* of the Germans is merely an imperfect slaty variety.—*Shale* or *Slate-clay* (*Schieferthon*), greyish-black, and much mixed with bituminous or carbonaceous matter, is common in the coal formation. *Bituminous shale* is known by its shining, resinous streak, and often contains so much combustible matter as to be used for fuel. In the *Black chalk*,—the *Zeichenschiefer*

of Werner, the *Schiste graphique* of Hauy,—there is more carbon, and the mineral leaves a black mark on paper. It becomes red or white in the fire, and is common in France, Spain, Italy, and Germany. The *Lemnian earth*, used as a medicine from the time of Homer to the present day, and sometimes named Sphragid, from the official mark impressed on the small balls in which it is sold, is found in the island of Lemnos. It is yellowish-grey or white, with ochreous spots on the surface; adheres slightly to the tongue, and falls to pieces in water; and seems only a decomposed trachyte. The *Iron clay (Eisenthon)* contains much peroxide of iron, and is reddish-brown. It forms the basis of many amygdaloids and porphyries, and also occurs in beds in recent formations. There are many other varieties of clay, but these are the more remarkable. The following are a few analyses of important varieties:—

	Silica.	Alumina.	Iron per.	Magnesia.	Lime.	Watr.	Total.	
1	57	43	...	...	...	11·2*f*	100	Berthier, Devonshire.
2	59	41	trace.	...	...	13–18*f*	100	Do. Dreux, France.
3	64·2	33·3	2·5	...	...	19*f*	100	Do. Andenne, Namour.
4	37·80	26·88	0·02	...	...	33·96	98·66	Leschen, Grossalmerode.
5	60·0	30·0	7·6	...	2·4	18*f*	100	Berthier, Figeac.
6	60·00	17·60	15·21	...	2·36	...	95·17	Walker, Wardie, Edinburgh.
7	58·22	17·30	10·53*a*	4·62	traceb	6·70	99·59	Do. Lochend, Do.
8	50·20	21·00	0·90	...	... *c*	8·22	98·43	Lampadius, Schonfeld, Saxony.
9	57·59	12·92	0·87	0·57	... *d*	6·30	99·79	Fuchs, Bayreuth.
10	66·00	14·50	6·00	0·25	0·25*e*	8·50	99·00	Klaproth, Lemnos.

(*a*) Protoxide; (*b*) + 2·02 soda; (*c*) + 18·11 carbon; (*d*) + 4·02 soda and potash; and 17·52 carbon; (*e*) + 3·50 soda; (*f*) per cent.

1–4, Pipeclay; 5, potters' clay; 6, 7, 8, slate-clay; 9, black chalk; 10. Lemnian earth.

122. ROCK-SOAP, Bergseife, *Werner;* Savon de montagne, *Beudant.*

Compact; fracture earthy or conchoidal; sectile; H. = 1 — 2; Opaque; dull, streak resinous; colour pitch-black and bluish-black; feels very greasy; writes, but does not soil; adheres strongly to the tongue, and falls to pieces in water. Chem. com. indeterminate. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Magnesia.	Mang. perox.	Watr.	Total.	
1	44·0	26·5	8·0	0·5	...	...	20·5	99·5	Bucholz, Artern Thuringia.
2	23·3	16·1	10·3	1·1	3·1	3·1	43·0	100	Ficinus, Arnstedt.
3	46·44	17·40	6·22	0·86	1·25	0·10	12·69*a*	99·48	Beckman, Cassel.
4	44·0	22 0	...	...	2·0	...	25·05	99·0	Berthier, Plombières.

(*a*) + 0·55 phosphoric acid, 6·95 carbon, 6·46 humic acid, 0·56 bitumen; (*b*) + 6·0 sand.

No. 4 much resembles bole. Rock-soap also occurs at Bilin in Bohemia, Olkuce in Poland, and in basalt in the Isle of Skye. It is used for crayons by painters, and for washing cloth.

123. PLINTHITE, *Thomson.*

Compact; fracture flat conchoidal and earthy; H. = 2—3; G. = 2·34. Opaque; glimmering or dull; brick-red or brownish-red; does not adhere to the tongue. B.B. becomes black, but not magnetic; and is infusible alone or with borax. It contains 30·88 silica, 20·76 alumina, 26·16 iron peroxide, 2·60 lime, and 19·60 water (= 100) Thomson. This gives no simple formula, but if the lime be omitted, then $(\ddot{a}\dot{i}, \ddot{r}\dot{o})$, $\ddot{s}\dot{i} + 3\dot{h}$, *Rammelsberg.* It occurs at Antrim in Ireland. The *Erinite* of Thomson from the same place is very similar; it contains 47·0 silica, 18·5 alumina, 6·4 iron peroxide, 1 lime, 25·3 water, 0·9 common salt, and trace of magnesia (= 99·0); and is probably a variety of bole.

124. GREEN-EARTH, Grunerde, *Germans;* Terre verte, *French.*

Occurs massive in amygdaloids, forming crusts, or as a pseudomorph after augite or other minerals; fracture uneven, fine earthy; sectile; H. = 1—2; G. = 2·8. Opaque; dull, but streak shining; colour various shades of green; feels greasy. B.B. fuses to a black magnetic glass; not affected by acids before or after ignition. Chem. com. very various; many are fine scaly or earthy chlorite. Analyses.

	Silica.	Alumina.	Iron perox.	Magnesia.	Lime.	Potash.	Watr.	Total.	
1	51·00	12·00	17·00	3·50	2·50	trace *a*	9·00	99·50	Klaproth, East Prussia.
2	51·50	...	20·50	1·50	...	13·00	8·00	99·50	Do. Cyprus.
3	53·0	...	28·0	2·0	...	10·0	6·0	99·0	Do. Monte Baldo.
4	52·0	7·0	23·0	6·0	trace	7·5	4·05	99·5	Vauquelin, Do.

(*a*) + 4·50 soda; (*b*) traces of manganese peroxide and muriatic acid.

The green-earth used in the arts comes chiefly from Monte Baldo near Verona and Cyprus, but varies much in composition, and is often adulterated. Common green-earth is abundant in the trap rocks of Faroe, Iceland, Scotland, and other countries.

The *Glauconite*, which forms small round grains in the green-sand of England, France, Germany, and North America, is very similar both in colour and other properties, but seems essentially a hydrous silicate of iron protoxide and potash. Analyses.

	Silica.	Alumina.	Iron prot.	Magnesia.	Lime.	Potash.	Watr.	Total.	
1	40·0	1·1	24·7	16·6	3·3	1·7	12·6	100·0	Berthier, Paris, Calc-grossière.
2	46·1	5·5	19·6	3·8	...	5·3	8·9 *a*	100·7	Do. Chalk, Germany.
3	49·7	6·9	19·5	...	...	10·6	12·0	98·7	Do. Do. Havre.
4	48·5	17·0	22·0	3·8	...	...	7·0	98·3	Turner, Greensand, England.
5	56·70	13·32	20·10	1·18	1·62	...	...	99·92	Dana, Do. Gay Head, Mass.
6	48·45	6·30	24·31	...	trace	12·01	8·40	99·47	Rogers, Do. Woodstown, N.J.
7	51·50	6·40	24·30	trace	...	9·96	7·70	99·86	Do. Do. Sculltown, Do.
8	50·75	6·50	22·14	...	...	12·96	7·50	99·85	Do. Do. Burlington.

(*a*) + 11·5 quartz.

125. YELLOW-EARTH, *Jameson;* Gelberde, *Werner;* Argile ochreuse jaune, *Hauy.*

Compact and thick slaty; fracture fine earthy. H. = 1 — 2; G. = 2·2. Opaque, dull, or glimmering. Colour ochre-yellow. Feels greasy, adheres slightly to the tongue, and pulverizes in water. B.B. infusible, but becomes red, and in the red. flame black. Partially soluble in hydrochloric acid. Kühn found 33·23 silica, 37·76 iron peroxide, 14·21 alumina, 1·38 magnesia, 13·24 water (= 99·82), in that from Amberg, in Bavaria; but other varieties differ, and it seems rather a mixture of hydrous silicate of alumina, with hydrated peroxide of iron, than any definite compound. It occurs also in the Harz, France, Scotland, and other places, and is used as a coarse pigment.

126. HALLOYSITE, *Berthier*

Amorphous, reniform; H. = 1·5 — 2·5; G. = 1·9 — 2·1. Opaque or semitranslucent. Colour white, inclining to blue, green, or yellow. Adheres slightly to the tongue. Becomes more translucent when moist. In closed tube yields water. B.B. infusible, but becomes blue with cobalt solution. Soluble in concentrated sulphuric acid. Chem. com. nearly $\dot{A}l\,\ddot{S}i^2 + 4\dot{H}$, = 41·5 silica, 34·4 alumina, and 24·1 water. Analyses.

	Silica.	Alumina.	Magnesia.	Watr.	Total.	
1	44·94	39·06	...	16·00	100	Berthier, Anglar, near Liege.
2	46·7	36·9	...	16·0	99·6	Do. Housseha, near Bayonne.
3	46·0	40·2	...	14·8	100	Boussingault, Guateque, N. Granada.
4	40·66	33·66	...	24·83	99·15	Dufrénoy, la Vouth, France.
5	43·10	32·45	1·70	22·30	99·55	Do. Thiviers, Do.
6	37·5	37·5	...	25·0	100	John, Kall, Eifel (Lenzinite.)
7	44·30	40·40	0·50*a*	13·50	99·45	Thomson (Tuesite.)

(*a*) 0·75 lime.

Besides the above, this substance is found in other localities. No. 6 is the Lenzinite, much resembling the above, but differing somewhat in composition. No. 7 is the Tuesite of Thomson, from the banks of the Tweed; bluish-white and steatitic, with sp. gr. = 2·5.

127. FULLER'S-EARTH, *Phillips;* Walkerde, *Werner.*

Fracture uneven, imperfect conchoidal, slaty or earthy. H. = 1 — 1·5; G. = 1·8 — 2·0. Opaque; dull, but streak resinous. Colour green, grey, or white. Feels very greasy. Scarcely adheres to the tongue. Falls down in water, but does not become plastic. Analyses, next page.

	Silica.	Alumina.	Iron perox	Magnesia.	Lime.	Common salt.	Watr.	Total.	
1	53·00	10·00	9·75	1·25	0·50	0·10	24·00	98·60	Klaproth, Riegate.
2	49·50	15·50	6·50	1·50	...	trace.	25·50	97·50	Do. Nimptsch, Silesia.
3	57·11	31·85	2·62	...	...	...	7·28	98·86	Thomson, Maxton.

This substance occurs in whole beds in the oolite and chalk formations, and is rather a rock than a simple mineral. It is used in preparing cloth,—the best for this purpose being found in England, as at Riegate in Surrey, Maidstone in Kent, Woburn in Bedfordshire, &c. Also in Saxony, Bohemia, Styria, and other countries.

128. ALLOPHANE, *Stromeyer, &c.;* Lamprochromatic Opallin-allophane, *Mohs.*

Massive, botryoidal, and reniform, disseminated or investing. Fracture conchoidal, brittle. H. = 3; G. = 1·8—2. Transparent or translucent; vitreous; colour pale-blue, white, green, or brown. In the closed tube yields water, and becomes partly black. B.B. intumesces, but does not fuse, becomes white, and colours the flame green. With soda shows reaction for copper. Soluble and gelatinizing in acids. Chem. com. variable, but often near $\dot{A}i\,\dot{s}i + 5\dot{H}$, with 24·3 silica, 40·4 alumina, and 35·3 water. Analyses.

	Silica.	Alumina.	Watr.	Copper oxide.	Total.	
1	24·11	38·76	36·75	2·33	100·95	Walchner, Gersbach, Baden.
2	23·76	39·68	35·74	0·65	99·83	Guillemin, Fermi, Aveyron.
3	21·05	30·37	40·23	...*a*	98·84	Bunsen, Friesdorf, Bonn.
4	21·9	29·2	44·2	4·7*b*	100	Berthier, Beuvais (translucent.)
5	26·3	34·2	38·0	1·5*b*	100	Do. Do. (pulverulent.)

(*a*) + 2·74 iron peroxide, 2·39 carbonate of lime, 2·06 carbonate of magnesia; (*b*) clay.

Besides these localities, found also at Grafenthal near Saalfeld, Grossarl in Salzburg, at Petrow in Moravia, and other places. It seems often a secondary product of decomposition.

129. SCHRÖTTERITE, *Glocker.*

Amorphous, fracture conchoidal. H. = 3 — 3·5; G. = 1·95 — 2·05; colour greenish, sometimes yellowish, or with brown spots. In closed tube yields much water. B.B. is infusible, but burns white. Gelatinizes in hydrochloric acid. Chem. com. $\dot{A}i^5\,\dot{s}i^2 + 20\,\dot{H}$. The mean of two analyses by Schrötter gave 11·94 silica, 46·29 alumina, 35·85 water, 2·80 iron peroxide, 0·25 copper protoxide, 1·16 lime, 0·68 sulphuric acid (= 98·92). It occurs near Freienstein in Styria.

130. Challilite, *Thomson.*

Compact; fracture splintery and flat conchoidal. H. = 4·5; G. = 2·252. Translucent on the edges; vitreous or resinous; dark reddish-brown. B.B. becomes white, and melts with borax to a colourless glass. Thomson's analysis gave 36·56 silica, 26·20 alumina, 10·28 lime, 9·28 iron peroxide, 2·72 soda, and 16·66 water (= 101·70). It is from Sandy Brae, Antrim, and not unlike the Thomsonite in composition.

131. Bole, *Werner, Phillips, &c.*

Compact, earthy, in nests and veins. Fracture conchoidal. Sectile or slightly brittle. H. = 1 — 2; G. = 2·2 — 2·5. Opaque or translucent on the edges. Lustre dull resinous, streak shining. Colour brown, yellow, or red. Feels more or less greasy; some adhere strongly to the tongue, others not at all. In water crackle and fall to pieces. B.B. become hard by burning, and generally fuse to an enamel. In acids are more or less soluble. Chem. com. hydrous silicates of alumina and iron peroxide in various proportions. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Magnesia.	Water.	Total.	
1	42·00	24·04	10·03	0·52	0·43	24·03	101·05	Löwig, Ettingshausen.
2	41·05	25·03	8·09	0·45	0·50	24·02	99·14	Do. Cap de Prudelles.
3	41·9	20·9	12·2	...	...	24·9	99·9	Wackenroder, Säsebühl.
4	42·00	20·12	8·53	2·81	2·01	24·00*a*	99·97	Zellner, Striegau.
5	45·12	22·15	trace	3·90	trace	25·86	97·83	Rammelsberg, Stolpen.
6	32·0	26·5	21·0	...	1·5*b*	17·0	98·0	Klaproth, Sinope.
7	31·3	43·0	1·2	...	...*c*	21·0	96·5	Kersten, Orawitza.
8	46·40	3·01	23·50	...	...	24·50	97·41	Do. Halsbrücke.

(*a*) + 0·50 potash; (*b*) = chloride of sodium; (*c*) + trace of boracic acid.

Bole is common in basaltic rocks, as in the Säsebühl near Dransfeld in Hanover, and at Stolpen, or as a contact product near igneous rocks, as at Cap de Prudelles near Clermont, Auvergne. It also occurs in the trap rocks of the Hebrides and other parts of Scotland, and in Ireland. No. 6, the *Sinopite*, of a red colour, is brought from Asia Minor, and is supposed to be the Sinopian earth of antiquity. No. 7, the *Fettbol*, from near Freiberg, is named from its greasy feel. No. 8 is the Ochran of Breithaupt, of a yellow colour. The last two are infusible B.B., and the loss consists in boracic acid or an alkali.

132. Teratolite, *Glocker;* Hard Lithomarge, Eisensteinmark, *Werner, &c.*

Compact. Fracture uneven, flat conchoidal, or earthy. H. = 2.5 — 3; G. = 2·5. Opaque; dull; colour lavender-blue to plum-blue, often with reddish-white veins and spots. Feels rough and meagre. B.B. infusible; with borax gives colour of iron. Schuler's analysis

gave 41·66 silica, 22·85 alumina, 12·98 iron peroxide, 3·04 lime, 2·55 magnesia, 0·93 potash, 1·68 manganese peroxide, 14·20 water (= 99·89). It occurs in beds in the coal formation of Planitz near Zwickau in Saxony, and is the Terra miraculosa Saxoniæ of old authors, valued for its supposed medicinal properties.

133. Kollyrite, *Freiesleben.*

Compact, fine-earthy; fracture even or flat conchoidal. H. = 1—2; G. = 2·0—2·15. Semi-translucent or opaque; dull or glimmering; snow-white, rarely reddish, greenish, or yellowish. Feels greasy, and adheres strongly to the tongue. B.B. infusible, becomes blue with cobalt solution. Gelatinizes imperfectly with acids. Chem. com. of Nos. 1 and 2, $\dddot{\text{Al}}^2\,\dot{\text{Si}} + 10\,\dot{\text{H}}$. Analyses.

	Silica.	Alumina.	Watr.	Iron perox.	Total.	
1	14	45	42	...	101	Klaproth, Schemnitz.
2	15·0	44·5	40·5	...	100	Berthier, Ezquerra, Pyrenees.
3	23·3	42·8	34·7	..	100·8	Kersten, Weissenfels, Saxony.
4	7·90	42·75	48·55	0·80	100	Vernon, Scarborough.

The Saxon variety (No. 3), found in sandstone, differs from the two others, which occur, the former in trachyte, the latter as a crust on quartz rock. No. 4, the *Scarbroite*, from limestone, is similar, G. = 1·485, but probably a mixture.

134. Lithomarge; Steinmark, *Werner, &c.*

Under this name many distinct substances are comprised, some mere products of decomposition. In general they are compact, earthy, or pseudomorphous. Fracture fine earthy, uneven or flat conchoidal; H. = 2·5—3·0; G. = 2·4—2·6. Opaque, or dimly translucent. Lustre dull. Colour white, yellow, or red. Feel greasy, and adhere more or less to the tongue. Analyses.

	Silica.	Alumina.	Iron perox.	Potash.	Lime.	Watr.	Total.	
1	45·25	36·50	2·75	trace	...	14·00	98·50	Klaproth, Rochlitz, Saxony.
2	58	32	2	...	...	7	99	Do. Oemrichsberg, Silesia.
3	49·2	36·2	0·5	...	...	14·0	99·9	Zellner, Buchberge, Landshut.
4	43·00	40·25	0·48	...	0·47	15·50	99·70	Dumenil, Clausthal.
5	49·75	29·88	6·61	6·35	0·43*a*	5·48	99·97	Rammelsberg, Zorge, Harz.
6	43·46	41·48*b*	...	...	1·20*c*	13·49	100	Do. Schlackenwalde.

(*a*) + 1·47 magnesia; (*b*) with peroxide of iron and manganese; (*c*) + 0·37 soda.

No. 1 is named *Carnat* by Breithaupt, from its fine red colour. No. 2 is a so-called crystallised lithomarge, probably a pseudomorph

of felspar found in a decomposed porphyry, near Flachenseifen. No. 4 is a white phosphorescing variety from a mine in the Harz, G. = 1·59. No. 5 is green, G. = 3·086. No. 6 white and radiated; yielded water in the closed tube, and B.B. emitted a strong light and became hard without fusing.

The *Myelin* of Breithaupt, or *Talksteinmark*, from Rochlitz in Saxony, is reniform or curved lamellar; pale-yellow or flesh-red. B.B. infusible, but becomes blue with cobalt solution. According to Kersten, it contains 37·62 silica, 60·50 alumina, 0·82 magnesia, and 0·63 peroxide of manganese, with a trace of iron peroxide (= 99·57). It is thus nearly a compact cyanite or andalusite; but Breithaupt finds in it 5 per cent. water. The *Melopsite* of Breithaupt, yellowish or greenish-white, from Neudeck in Bohemia, seems impure. It consists, according to Plattner, of silica, alumina, some magnesia and iron peroxide, with water and traces of ammonia.

135. MILOSCHIN, *v. Herder;* Serbian, *Breithaupt.*

Compact. Fracture conchoidal and smooth, or earthy; H. = 2; G. = 2·13. Colour indigo-blue to celadine-green. Adheres to the tongue and crackles in water. B.B infusible. Partially soluble in hydrochloric acid. Chem. com. ($\dot{A}l$, $\dot{C}r$) $\ddot{S}i$ + 3 $\dot{H}$. Analysis by Kersten; 27·50 silica, 45·01 alumina, 3·61 chrome oxide, 0·30 lime, 0·20 magnesia, 23·30 water, with traces of potash and iron peroxide, (= 99·92). Occurs at Rudniak in Servia.

136. KEROLITE, *Breithaupt.*

Massive reniform. Fracture uneven, or smooth conchoidal, or seldom splintery. Rather brittle; H. = 2 — 3; G. = 2·3 — 2·4. Translucent; dull resinous lustre. Colour white, inclining to grey, yellow, green, or red. Feels greasy, but does not adhere to the tongue. In the closed tube yields water, and becomes black. B.B. is infusible, but colours the flame pale-red. Analyses.

	Silica.	Alumina.	Magnesia.	Iron prot.	Watr.	Total.	
1	37·95	12·18	18·02	...	31·00	99·15	Maak, Frankenstein, Silesia.
2	47·13	2·57	36·13	2·92	11·50	100·25	Melling, Zöblitz, Saxony.
3	53·5	0·9	28·6	..	16·4	99·4	Delesse, Do. ? (G. = 2·335).
4	46·96	...	31·26	...	21·22	99·44	Kühn, Silesia.

Each analysis leads to a different result, and the minerals are probably distinct species. The characters above refer especially to No. 1. No. 2 occurs in serpentine, and, except the alumina, nearly agrees with this rock in composition.

137. AGALMATOLITE, *v. Leonhard*; Figure-stone, *Phillips*; Pagodite, Bildstein, *Werner*; Talc-glaphique, *Hauy*.

Massive, imperfectly slaty. Fracture splintery. Rather sectile. H. = 2 — 3; G. = 2·8 — 2·9. Translucent or only on the edges. Lustre dull or glimmering. Colour various shades of green, grey, red, and yellow. Feels somewhat greasy, but does not adhere to the tongue. B.B. burns white and fuses slightly on very thin edges. Not decomposed by salt of phosphorus. Soluble in warm sulphuric acid. Chem. com. $4\,\ddot{A}i\,\ddot{S}i^2 + \dot{K}\,\ddot{S}i^3 + 3\,\dot{H} = 55$ silica, 33·1 alumina, 7·6 potash, and 4·4 water. Analyses.

	Silica.	Alumina.	Iron perox.	Lime.	Potash.	Water.	Total.	
1	56·0	29·0	1·0	2·0	7·0	5·0	100	Vauquelin, China.
2	54·50	34·00	0·75	...	6·25	4·00	99·50	Klaproth, Do.
3	55·0	33·0	0·5	...	7·0	3·0	98·5	Do. Nagyag.
4	55·50	30·00	1·00 *a*	1·75	6·25	5·50	100	John, China.
5	51·50	32·50	1·75 *b*	3·00	6·00	5·13	100	Do. Saxony.
6	49·82	29·39	1·50	6·00	6·80	5·50	99·21	Thomson, China.
7	72·40	24·54	2·85	(*c*)	...	...	99·79	Lychnell, Do.
8	54·0	26·5	1·5	...	5·5	12·0	99·5	Klaproth, Argentiera.

(*a*) + trace of manganese peroxide; (*b*) + 0·12 manganese peroxide; (*c*) trace of magnesia.

No. 7 was probably some other mineral, and many substances are named agalmatolite which are in reality distinct. It occurs especially in China, where it is cut into various works of art. It is also found at Nagyag in Hungary, and in beds in mica slate on the Ochsenkopf in Saxony. Also, it is said, in Wales. The *Cimolite* of Klaproth (No. 8 above) is a pure white clay from the island of Argentiera, and probably a mere product of decomposition of trachyte or other felspar rock. It is also found in Milo, and used for cleaning cloth.

138. SOAPSTONE, *Phillips*; Seifenstein, *Werner*; Pierre de Savon, *Hauy*.

Massive. Sectile and very soft. H. = 1·5; G. = 2·26. Colour white, or light grey, yellow, and reddish-brown. Streak shining; feels greasy, and writes feebly. Does not adhere to the tongue. In the closed tube yields water. B.B. fuses to a colourless porous glass. Soluble in sulphuric acid. Analyses.

	Silica.	Alumina.	Magnesia.	Iron perox.	Lime.	Water.	Total.	
1	45·00	9·25	24·7	1·00	...*a*	18·00	98·75	Klaproth, Cornwall.
2	46·8	8·0	33·3	0·4	0·7	11·0	100·2	Svanberg, Do.
3	50·89	9·40	26·52	2·06	0·78	10·50	100·15	Do. Svärdsjö.

(*a*) + 0·75 potash.

The soapstone is found at the Lizard Point (No. 1) in Cornwall in veins in serpentine, and also at St Clear. No. 3, from Dalarne in

Sweden, seems the same mineral. The difference in the amount of water arises from Klaproth's specimen not being dried before analysis. This mineral is easily distinguished from steatite by its action before the blowpipe.

139. Pipestone, *Thomson.*

Compact; fracture earthy; sectile; H. = 1·5; G. = 2·6; opaque, dull, and greyish-blue or black. B.B. infusible. Analyses.

	Silica.	Alumina.	Iron perox.	Magnesia.	Lime.	Soda.	Watr.	Total.	
1	56·11	17·31	6·96	0·20	2·17	12·48	4·58	99·81	Thomson, Oregon.
2	48·2	28·2	5·0	6·0	2 6*a*	...	8·4	99·0	Jackson, Catlinite.

(*a*) Carbonate of lime + 0·6 manganese peroxide.

No. 2, the *Catlinite* of Jackson, from the Coteau de Praires, is of a red colour, and highly prized by the Indians as a material for pipes.

140. Meerschaum, *Werner, Jameson;* Earthy Carbonate of Magnesia.

Compact; fracture flat conchoidal and fine earthy; sectile; H. = 2 — 2·5; G. = 0·8 — 1·0 (when moist nearly 2). Opaque; dull, streak slightly shining; colour yellowish and greyish-white; feels rather greasy, and adheres strongly to the tongue; in the closed tube gives out water, and becomes black. B.B. contracts, becomes hard, and fuses on the edges to a white enamel. With solution of cobalt becomes pale-red. Soluble in hydrochloric acid, leaving slimy flakes of silica. Chem. com. $\dot{M}g^2\,\ddot{S}i^3 + 2\dot{H}$, according to Lychnell's analysis of the mineral dried in vacuum over sulphuric acid; others give twice the amount of water, or 4 $\dot{H}$. Analyses.

	Silica.	Magnesia.	Alumina.	Iron perox.	Lime.	Watr.	Total.	
1	50·50	17·25	...	...	0·50*a*	25·00	93·25	Klaproth, Asia Minor.
2	50·0	25·0	...	...	...	25·0	100	Berthier, Do.
3	60·87	27·80	0·095	...	...	11·29	100·05	Lychnell, Do.
4	53·8	23·8	1·2	...	...	20·0	98·8	Berthier, Madrid.
5	54·0	24·0	1·4	...	...	20·0	99·4	Do. Coulommiers.
6	48·00	20·06	...	12·40	...	19·60	100·06	v. Kobell, Greece.
7	55·00	29·00	1·20	1·40	1·01*c*	10·35	98·93	Damour, Morocco.
8	51·57	33·90	0·16	0·57*d*	...	11·63	99·58	Berlin, (Aphrodite).

(*a*) + 5·00 carbonic acid; (*b*) with iron peroxide; (*c*) + 0·52 potash, and 1·50 sand; (*d*) protoxide + 1·55 manganese protoxide.

Klaproth's analysis (No. 1) is remarkable for the carbonic acid. Von Kobell thinks the iron in No. 6, a yellowish-red variety, was mixed as a hydrate.

Meerschaum comes chiefly from Kiltschik near Konie in Asia Minor. It also occurs near Thebes, and in other parts of Greece, along with semiopal; in Spain it forms beds in marl at Valecas near Madrid and near Toledo; and at Pinheiro in Portugal, in syenite. At Hrubschitz in Moravia it occurs in serpentine. The so-called meerschaum from the Taberge and Sala in Sweden, is shown by Berlin to be serpentine. That from Längsbanshytta in Wermeland (No. 8), he makes a distinct species named *Aphrodite*, G. = 2·21; but it agrees in most points with meerschaum. This substance is chiefly used in forming heads for tobacco pipes.

141. Pimelite, *Karsten.*

Massive, fracture conchoidal, H. = 2·5; G. = 2·23—2·3. Translucent, dull resinous; colour apple-green, streak greenish-white. Feels greasy, but does not adhere to the tongue. According to Berzelius, gives water in the closed tube and becomes black. Melts to a slag only on thin edges. With borax, shows reaction for nickel. Chem. com. unknown. The pimelite or chrysoprase-earth, analysed by Klaproth, was apparently a mixture. In another from Frankenstein in Silesia, Schmidt found 54·68 silica, 32·66 nickel oxide, 5·89 magnesia, 0·16 lime, 1·13 iron protoxide, 0·30 alumina, and 5·23 water. It felt meagre and adhered to the tongue; G. = 1·458. The *Razoumoffskin* of John is by some united to pimelite, but the variety from Kosemutz in Silesia, analysed by Zellner, gave 54·50 silica, 27·25 alumina, 2·00 lime, 0·37 magnesia, 0·25 iron protoxide, and 14·25 water (= 98·62). This gives $\ddot{A}i\,\dot{S}i^3 + 3\dot{H}$, and it is probably distinct.

142. Dermatin, *Breithaupt.*

Compact or reniform. H. = 2·5; G. = 2·136. Resinous; colour blackish-green; streak yellowish-white. Does not adhere to the tongue. When breathed on, has an argillaceous smell. B.B. cracks and becomes black. Chem. com. $(\dot{M}g, \dot{F}e)\,\ddot{S}i + 2\dot{H}$. Analyses.

	Silica.	Magnesia.	Iron prot.	Mang. perox	Alumina.	Lime.	Soda.	Water & carb. ac.	Sulph. acid.	Total.	
1	35·90	23·70	11·33	2·25	0·42	0·83	0·50	25·20	...	100·03	Ficinus.
2	40·17	19·33	14·00	1·17	0·83	0·83	1·33	22·00	40·3	100·09	Do.

Occurs at Waldheim in Saxony in serpentine.

143. Retinalite, *Thomson.*

Massive and resinous-looking. Fracture splintery; H. = 3·5; G. = 2·493. Translucent, resinous, and brownish-yellow. B.B.

becomes white and friable without fusing. Forms with borax a colourless glass. Chem. com. very near $\dot{M}g^3\ \ddot{S}i^2 + 2\ \dot{N}a\ \ddot{S}i + 7\dot{H}$. Thomson found 40·55 silica, 18·36 magnesia, 18·83 soda, 0·62 iron peroxide, 0·30 alumina, and 20·00 water (= 99·16). From Granville in Upper Canada.

X. Family.—Garnet.

144. Garnet, *Phillips, &c.*; Granat, *Werner, &c.*; Grénat, *Hauy*; Dodecahedral Garnet, *Mohs, Jameson.*

Tesseral; most common forms ∞O (like fig. 3 above), and $2O2$ (fig. 6). These are often combined, and also $3O\frac{3}{2}$, $4O\frac{4}{3}$, and also others (figs. 21 and 22 above). The crystals are either imbedded singly, or are attached and combined in druses. Also in granular or compact masses. Cleavage dodecahedral, but very imperfect, and often not observable. Fracture conchoidal, or uneven and splintery. H. = 6·5 — 7·5; G. = 3·5 — 4·3. Pellucid in all degrees. Lustre vitreous or resinous. Rarely colourless or white; generally red, brown, black, green, or yellow, according to their composition. B.B. in general fuse easily to a glass, black or grey, in those containing much iron, green or brown in the others, and often magnetic. Imperfectly soluble in hydrochloric acid; some wholly, after long digestion, leaving the silica in powder. After strong ignition the more calcareous varieties are easily decomposed and gelatinize; the others must first be almost or entirely fused. Chem. com. exceedingly variable, but generally $\dot{R}^3\ \ddot{S}i^2 + \ddot{R}\ \ddot{S}i$. They then form two series, according as $\ddot{R}$ is chiefly alumina or chiefly iron peroxide: and these are again divided according as $\dot{R}$ is more especially lime, iron protoxide, magnesia, or similar bases. Analysis, however, shows that these varieties are rarely pure, but are mixed with or pass into each other. Analyses, next page.

This table contains only a mere selection from the very numerous analyses of this mineral, so highly interesting from its bearing on the doctrine of isomorphism. It shows that no one of the bases is constant in its occurrence, but that any one of them may be replaced in whole or part by other elements. The silica also in some seems to be replaced in part by alumina. Hence many varieties of this mineral have been distinguished partly from chemical, partly from physical characters, the more important being the following:—

(1.) *Almandine*, or noble garnet, is columbine-red inclining to violet, blood-red, or reddish-brown; streak white; transparent or

	Silica.	Alumina.	Iron perox	Iron prot.	Mang. protox.	Lime.	Magnesia.	Total.	
1	39·62	19·30	...	34·05	0·85	3·28	2·00	99·10	Karsten, Greiner.
2	39·85	20·60	...	24·85	0·46	3·51	9·93	99·20	Do. Greenland.
3	39·12	21·08	6·00	27·28	0·80	5·76	...	100·04	v. Kobell, Greiner.
4	40·56	20·61	5·00	32·70	1·47	...	...	100·34	Do. Hungary.
5	38·25	19·35	7·33	...	0·50	31·75	2·40	99 58	Karsten, Wilui river.
6	40·55	20·10	5·00	...	0·48	34·86	...	100·99	Trolle-Wachtmeister, Do.
7	39·60	21·20	...	2·00	3·15	32·30	...	98 25	Do. Tellemark.
8	36·86	24·19	...	...	...	37·15	...	98·20	Croft, Slatoust.
9	38·80	21·20	6·50	a.	...	31·25	...	97·75	Klaproth, Ceylon.
10	41·87	20·57	3·93	...	...	33·94	0·39*a*	100·70	Arfvedson, Malsjo.
11	41·24	24·08	7·02	...	0·926	24·76	...	100·10	Nordenskiöld, Kimito.
12	37·82	19·70	5·95	...	0·15	31·35	4·15	99·12	Karsten, St Gotthardt.
13	39·93	13·45	10·95	3·55	1·40	31·66	...	100·94	Tr.-Wachtmeister, Vesuvius.
14	42·45	22·47	...	9·29	6·27	6·53	13·43	100·44	Do. Arendal.
15	36·73	2·78	25·83	...	...	21·79	12·44	99·57	Bredberg, Sala.
16	35·10	...	29·10	...	7·48	26 91	...*c*	99·17	Tr.-Wach., Längsbanshytta.
17	38·12	7·32	19·42	...	3·30	31·65	...*d*	100·00	Do. Hesselkulla, green.
18	37·99	2·71	28·52	...	0·62	30·74	...	100·58	Do. Do. brown.
19	40·20	6·95	20·50	...	4·00	29·48	...	101·13	Do. Arendal.
20	39·64	...	30·00	...	3·02	29·21	...*e*	100·22	Do. Altenau, Harz.
21	38·00	6·00	28·06	...	...	29·00	...	101·06	Seybert, Lake Champlain.
22	37·00	5·00	18·50	...	6·25*f*	30·00	...	96·75	Rose, Drammen.
23	33·72	7·97	17·64	...	16·70	22·68	...	98·91	Thomson, Franklin, N. A.
24	35·50	6·01	26·00	...	0·40*f*	32·50	...	100·40	Klaproth, Frascati.
25	34·60	4·55	28·15	...	...	31·80	0·65	99·75	Karsten, Do.
26	36·45	2·06	29·48	...	0·28	30·76	0·06*g*	100·05	Ebelmen, Beaujeux.
27	37·60	14·40	13·35	...	...	27·80	6·55*h*	100·70	Richardson, Norway.
		f			Chrome perox.				
28	37·11	5·88	...	2·44	22·54	30·34	1·10*k*	100·42	Komonen, Bissersk.
29	36·93	5·68	1·96	...	21·94	31·63	1·54*l*	99·58	Erdmann, Ural.
30	35·57	6·25*i*	...	...	23·45	33·22	...	98·49	Damour, Do.

(*a*) With manganese protoxide; (*b*) with magnesia + 1·98 volatile and loss; (*c*) + 0·98 potash; (*d*) + 0·18 carbonic acid and loss; (*e*) + 2·35 potash; (*f*) peroxide; (*g*) + 0·96 loss by heat; (*h*) + 1·00 water; (*i*) with iron peroxide; (*k*) + 1·01 water; (*l*) trace of copper.

translucent; sometimes magnetic. Analyses, No. 1–4, and hence an iron-alumina garnet with special composition, $\dot{F}e^3\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i$, with 37 silica, 20·1 alumina, and 42·9 iron protoxide. It is common in mica, talc, chlorite, and hornblende slates, also in gneiss and granite, in distinct crystals or grains often very small. Occasionally it forms subordinate beds, and more rarely veins. The finest specimens are brought from Pegu, Ceylon, and the East; others from Brazil, and a blood-red variety from Greenland. Large crystals, but inferior in beauty and transparency, occur at Fahlun, Arendal, Kongsberg, the Tyrol, the Ural, and in North America. It is common in the mica-slates of Perth, Inverness, and Zetland. It is used as an ornamental stone. The Tyte-Quärner, or Norwegian millstones, found at Selboe, is a mica-slate with numerous minute garnets; and similar millstones of excellent quality are procured on the Simplon.

(2.) *Lime-alumina-garnets*, consisting essentially of $\dot{C}a^3\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i$ with 40·7 silica, 22·5 alumina, and 36·8 lime. To these belong

(*a*) The *Grossular*, pale gooseberry-green, sometimes greenish-white, to mountain or olive-green, and translucent. It occurs with

Vesuvian in a serpentine-like rock on the Wilui river, Siberia; white and massive in chlorite-slate in the Ural, and white crystallized at Tellemark, Norway. Analyses, Nos. 5–8.

(*b*) *Cinnamon-stone*, *Hessonite*, or *Kaneelstein*, is usually hyacinth-red to honey or orange-yellow, and transparent or translucent. It is found in gneiss or in loose grains in Ceylon (No. 9), and Berzelius discovered a similar mineral (No. 10), in limestone in Wermeland. The *Romanzowite* (No. 11), from limestone at Kimito, Finnland, is also similar, part of the iron being probably protoxide. When polished, this variety is often named Hyacinth.

(*c*) *Common lime-garnet*, of various, more or less pure, red, brown, yellow, or green colours, and with part at least of the alumina replaced by iron peroxide. Analyses, Nos. 12, 13. This is the most abundant of the lime-alumina-garnets, occurring in the crystalline rocks in single crystals or in druses, and also in subordinate beds or veins, as in Piemont, the Ural at Slatoust, and in North America; also on Vesuvius in ejected blocks.

(3.) *Magnesia-garnet*, in which $\dot{R}$ is chiefly magnesia, opaque, lustre rather resinous; colour coal-black; streak dark-grey; G. = 3·157. B.B. fuses easily with bright light, and effervescing to a dark greyish-green non-magnetic globule, and is not affected by acids. It is found with calc-spar at Arendal, No. 14.

(4.) *Iron garnets*, consisting essentially of $\dot{C}a^3\ \ddot{S}i^2 + \ddot{F}e\ \ddot{S}i$, with 36·2 silica, 31·1 iron peroxide, and 33·6 lime. G. Rose states this variety to be more difficultly fusible and more easily soluble in hydrochloric acid than the others.

(*a*) *Common iron-garnet*, crystallized, granular, or compact. Subtranslucent or opaque, green, brown, yellow, or black, with white, grey, or yellow streak. Analyses Nos. 15—23, No. 16 being the *Rothoffite*, distinguished by the amount of manganese, and No. 22 the *Allochroite*. It occurs in the crystalline, or rarely in the transition, rocks, forming subordinate beds either alone, or more frequently mixed with other silicates, or with calc-spar. It is often associated with magnetic or other ores of iron, when it promotes their fusibility and productiveness, and in some places is intentionally mixed with them, and named "green iron-ore." It is more rare in veins, or imbedded as in granular limestone. Fine specimens occur in Sweden and at Arendal.

(*b*) *Melanite*, black, opaque, in thin splinters translucent. Streak grey, slightly magnetic. Analyses Nos. 24, 25, 26. Klaproth makes the iron the proto-peroxide (= 24·25), which seems confirmed by the colour and magnetism of the mineral. It is found in the peperino at Albano, in loose crystals near Frascati, in the ejected

blocks on Vesuvius, and at Beaujeux in the Rhone department, France. Also massive in the magnetic iron ore at Svappavara in Torneo-Lappmark. The *Pyreneite* found in limestone in the Pic d'Ereslids near Barèges in the Pyrenees, seems also melanite.

(*c.*) *Colophonite*, yellowish-brown to pitch-black, also honey-yellow or hyacinth-red; streak white, lustre resinous. G. = 3·43. It occurs either in crystals with calc-spar, or in large coarse or fine granular masses in the magnetic iron-ore of Arendal. Analysis No. 27.

(5.) *Uwarowite*, or chrome-garnet, occurs in emerald-green dodecahedral crystals, with greenish-white streak, vitreous lustre, and translucent or only on the edges. Fracture imperfect conchoidal; G. = 3·418; H. = 7·5. B.B. is infusible alone, but with borax forms a clear chrome-green glass. Analyses Nos. 28, 29, 30. It is found with chromate of iron at Bissersk and Kyschtimsk in the Ural. It has been considered a distinct species, but may be included under garnet.

145. PYROPE, *Karsten, Phillips;* Almandine, *Beudant;* Hexahedral Garnet, *Mohs.*

Very rarely crystallized, in indistinct hexahedrons with rough convex faces. Generally in roundish grains, loose or imbedded. Cleavage, not perceptible; fracture conchoidal; H. = 7·5; G. = 3·7 — 3·8. Transparent or translucent; lustre vitreous; colour dark-hyacinth to blood-red. B.B. becomes black and opaque, but regains its colour and transparency on cooling; fuses with difficulty to a black glass; with borax shows reaction for chrome; not soluble in acids, but partially after fusion. Chem. com. uncertain. Analyses.

	Silica.	Alumina.	Iron perox.	Magnesia.	Lime.	Mang. perox.	Chromic acid.	Total.	
1	40·00	22·50	16·50	10·00	3·50	0·25	2·00	100·75	Klaproth, Bohemia.
2	43·70	22·40	11·48*a*	5·60	6·72	3·68*a*	7·68*b*	100·66	Trolle-Wachtmeister, Mero-
3	43·00	22·26	8·74	18·55	5·68	...	1·80*b*	100·36	v. Kobell, Do. [nitz.
4	42·80	23·65	9·31	10·67	4·78	0·25*a*	trace *b*	96·46	Connel, Elie in Fife.

(*a*) Protoxide; (*b*) chromium oxide.

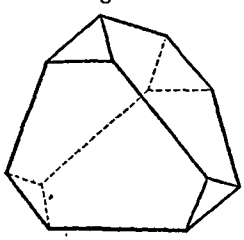
Some consider the chrome in the pyrope as the acid, others as the peroxide; and Rammelsberg in No. 2 changes it to 6·52 chromate of chrome-peroxide (chromsaures Chromoxyd). Its very variable amount in the Bohemian varieties, and the mere trace in that from Elie, show it to be probably an incidental mixture (chromate of iron). Connel's analysis gives nearly $\dot{R}\,\ddot{S}i + \dot{R}\,\ddot{S}i$, neglecting the loss; but if it was magnesia, then this will not apply. Naumann, from anal.

No. 3, proposes $\dot{R}^3 \ddot{S}i^2 + \ddot{A}l \ddot{S}i$, or the same with garnet, 3 $\dot{R}$ being 2 atoms magnesia, $\frac{1}{2}$ atom iron protoxide, and $\frac{1}{2}$ atom lime. Apjohn stated that the pyrope contains 3 per cent. yttria, which has not been confirmed.

Occurs in serpentine at Zöblitz in Saxony. In loose blocks of claystone near Meronitz, and more frequently in dispersed grains, as on the southern declivity of the Mittelgebirge near Podsedlitz and Trziblitz in Bohemia, where it is sought as an ornamental stone. At Elie in Fife it occurs in wacke or other trap rocks (Elie rubies). It is much valued as a gem, but is seldom of sufficient size.

146. HELVINE, *Werner*, *Hauy*, *Phillips*; Tetrahedral-garnet, *Mohs*. Tesseral, and tetrahedral; $\frac{O}{2}$ or the combination $\frac{O}{2}.\frac{O}{2}$ as in fig. 133. Crystals imbedded or attached. Cleavage, octahedral imperfect, H. = 6 — 6·5; G. = 3·1 — 3·3 (3·216, Breith.). Translucent on the edges. Lustre vitreous inclining to resinous; colour honey-yellow, wax-yellow, siskin-green, or yellowish-brown. Highly thermo-electric. B.B. in the red. flame fuses with intumescence to a yellow obscure pearl, becoming darker in the ox. flame. With borax forms a clear glass, becoming violet-blue in the ox. flame. With carbonate of soda in excess, on charcoal, forms a hepar, on platina wire a green glass coloured by manganese. Soluble in hydrochloric acid, evolving sulphuretted hydrogen, and gelatinizes. Chem. com. $Mn\ S + 3\dot{R}^2\ \ddot{S}i$, or according to Rammelsberg, $\dot{M}n, Mn\ S + (\dot{M}n, Fe, \dot{B}e)^2\ \ddot{S}i$. Analyses.

Fig. 133.



	Silica.	Glucina.	Iron prot.	Mang. prot.	Sulphur.	Sulph. of Mang.	Loss by heat.	Total.	
1	33·26	12·03*a*	5·56	31·82	...	14·00	1·55	97·82	C. Gmelin, Schwarzenberg.
2	35·27	8·03*b*	7·99	29.34	...	14·00	1·55	97·23	Do. Do.
3	33·26	12·03	5·56	44·68	5·057	...	...	101·10	No. 1 by Rammelsberg.
4	35·27	9·47	7·99	42·13	5·057	...	...	100·43	No. 2 Do. Do.

(*a*) With alumina; (*b*) + 1·45 alumina with glucina.

Nos. 3 and 4 are 1 and 2 recalculated, in accordance with the new views of the composition of glucina. Helvine occurs at Schwarzenberg in Saxony, with garnet, quartz, fluor, zinc-blende, and copper pyrites in beds in gneiss. Also found at Hortebulle near Modum in Norway, and, it is said, near Breitenbrun in Saxony.

147. IDOCRASE, *Hauy, Phillips;* Vesuvian, *Werner;* Pyramidal garnet, *Mohs.*

Tetragonal; P 74° 14′, *Mohs*, (varies from 73° 30′ to 74° 20′, *Kupffer* and *Breithaupt*). The more common forms are ∞P, ∞P∞, 0P, P, P∞ (56° 15′), ∞P3, with many subordinate, (fig. 134) comp. p. 22. The general aspect of the crystals is columnar, (fig. 135), from predominance of the prisms ∞P and ∞P∞; more rarely tabular or pyramidal when 0P or P prevails. Also occurs in columnar or granular masses. Cleavage, prismatic along ∞P∞ and ∞P, but imperfect; fracture uneven, splintery, or imperfect conchoidal. H = 6·5; G. = 3·35—3·45, (or even 4, *Breith.*). Transparent to translucent on the edges. Lustre vitreous or resinous. Various yellow, green, brown, almost black colours, rarely azure-blue or verdigris-green. Streak white. B.B. fuses easily with intumescence to a yellowish-green or brown glass. Colours borax from iron. Partially soluble in hydrochloric acid, after fusion wholly and gelatinizes. Chem. com. $\dot{C}a^3\,\ddot{S}i^2 + \dot{A}l\,\ddot{S}i$, or like garnet, with 40.2 silica, 37·1 lime, and 22·7 alumina. Analyses.

Fig. 134.

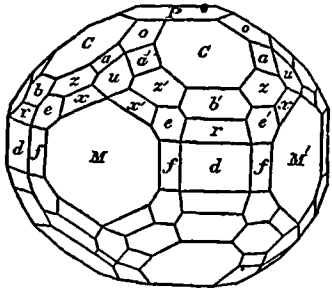


Fig. 135.

	Silica.	Alumina.	Lime.	Magnesia.	Iron prot.	Mang. prot.	Watr.	Total.	
1	35·50	22·25	33·00	...	7·50*a*	0·25*a*	...	98·50	Klaproth, Vesuvius.
2	36·00	17·50	37·65	2·52	5·25*b*	trace *b*	0·36	99·28	Berzelius, Gökum.
3	35·67	17·47	34·32	2·78	6·75*a*	0·31*a*	0·25	98·15	Murray, Do.
4	38·53	17·40	27·70	10·60	3·90	0·33*a*	...	98·46	Nordenskiöld, Frugård.
5	34·35	20·71	35·61	...	5·40	...	...	96·57	v. Kobell, Mussa Alp.
6	37·04	15·42	38·24	...	6·42	...	...	97·72	Do M. Monzoni.
7	37·18	18·11	35·79	0·77	4·67	1·50	...	98·02	Magnus, Slatoust.
8	38·62	20·06	32·41	2·99	3·42	0·02	...	97·42	Do. Cziklowa, Bannut.
9	37·66	17·69	31·90	4·54	6·49	0·50	...	98·78	Do. Egg, Norway.
10	37·36	23·53	29·68	5·21*b*	3·99	...	...	99·77	Do. Vesuvius.
11	37·50	18·50	33·71	3·10	6·25*a*	0·10	...	99·16	Karsten, Do.
12	39·25	18·10	33·85	2·70	4·30	0·75	...	98·95	Do. Piemont.
13	38·40	18·05	36·72	1·50	3·10	0·65	0·90*c*	99·32	Do. Sasser-Thal.
14	39·70	18·95	34·88	...	2·90	0·96	2·10*c*	99·49	Do. Hasslau, Bohemia.
15	35·09	17·43	33·08	2·00	6·37*a*	2·80	1·68	98·43	Thomson, Amity, N. Y.

(*a*) Peroxide; (*b*) with protoxide of manganese; (*c*) soda.

Idocrase differs from garnet chiefly in form. When fused, its specific gravity falls from 3·346 to 2·929—2·941 (Varrentrapp), agreeing with that of melted grossular-garnet. Hence, in the state of glass, the differences of the two substances disappear.

Idocrase was originally found in the ejected calcareous blocks on Vesuvius, in druses with garnet, augite, hornblende, &c. It also occurs imbedded or in druses in serpentine, marble, or chlorite-slate; but more commonly in subordinate beds with calc-spar, garnet, epidote, chlorite, and other silicates. Fine varieties are found on the Wilui river in Siberia; beautifully-coloured and transparent crystals on the Mussa-alpe in Piemont; large crystals, with numerous faces, at Egg near Christiansand in Norway; also at Wicklow in Ireland, and near Broadford in Skye in Scotland

The variety from Gökum (Nos. 2, 3) has been named *Gahnite, Loboite, Gökumite;* that from Finnland (No. 4), *Frugardite,* and that from near Eger (No. 14), *Egeran,* but there seems no sufficient ground for separating these from idocrase. The *Cyprine,* from Souland in Tellemark, Norway, seems also a variety. It is azure-blue or green, contains copper, and B.B. melts easily in the outer flame to a black, in the inner to a red pearl. The *Xanthite* of Thomson (No. 15), from a limestone bed near Amity in New York, in small, greyish-yellow, translucent, loosely-connected grains, also agrees nearly in composition with idocrase, which is found in same locality.

Idocrase is used as an ornamental stone, the brown being named hyacinth, the green chrysolite, but it is not highly valued.

Some furnace slags agree in many points with idocrase and the connected minerals. The following are a few analyses for comparison.

	Silica.	Alumina.	Lime.	Magnesia.	Iron prot.	Mang. prot.	Potash.	Sulpht. calcium	Total.	
1	38·05	14·11	35·70	7·61	1·27	0·40	1·85	0·82	99·81	Percy.
2	38·76	14·48	35·68	6·84	1·18	0·23	1·11	0·98	99·26	Do.
3	37·63	12·78	33·46	6·64	3·91	2·64	1·92	0·68	99·66	Do.
4	37·91	13·01	31·43	7·24	0·93	2·79	2·60	3·65	99·56	Forbes.
5	39 52	15·11	32·52	3·49	2·02	2·89	1·06	2·15	98·76	Do.

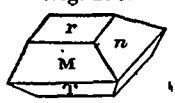
Nos. 1–4 were from hot-blast furnaces near Dudley; No. 5 from a cold-blast furnace near Tipton. Nos. 1–4 are described as crystallized in square prisms, terminated by planes perpendicular to the axis, and many with their angles truncated by planes, making equal angles with the adjacent faces, (or the tetragonal combination, $\infty P \cdot 0P \cdot m P\infty$.) G. = 2·905 — 2·924. Dr Percy gives for these five the formula $\dot{A}l\ \dot{S}i + 2\ (\dot{C}a, \dot{M}g, \dot{M}n, \dot{F}e)^3\ \dot{S}i$.

148. EPIDOTE, *Hauy, Phillips;* Prismatoidal Augite-spar, *Mohs.*

Monoclinohedric; dimensions variable. C = 89°, $\infty P2$ 63° 8′, $P\infty$ 64° 36′, $-P\infty$ 63° 43′, P 70° 9′, $-P$ 70° 33′. The crystals always appear horizontal-prismatic, prolonged in the direction of the orthodiagonal, and showing a predominance of the hemidomes with the

basal and orthodiagonal pinakoids. They often exhibit on the one, freely formed, end very complex combinations of hemipyramids and clinodomes. Common form, fig. 136, where ∞P∞ (M) . P∞ (T) . —P∞ (*r*) —P (*n*). The surface is often horizontally striated. The macles are united by a face of P∞. Crystals generally grouped in druses; also occurs massive and columnar, granular or compact. Cleavage, orthodiagonal very perfect, hemidomatic along P∞ rather perfect. Fracture conchoidal, uneven, or splintery. H. = 6 — 7; G. = 3·2 — 3·5. Pellucid in all degrees. Lustre vitreous, on cleavage planes adamantine. Coloured, especially green, yellow, and grey; rarely red and black. B.B. fusible. Strongly ignited, or after fusion all are soluble in hydrochloric acid, and gelatinize. Chem. com. variable, but nearly $\dot{Ca}^3 \ddot{S}i^2 + 2\dddot{R} \ddot{S}i$, the lime partly replaced by magnesia or protoxide of iron or manganese; and $\dddot{R}$ in some chiefly alumina, in others iron or manganese peroxide.

Fig. 136.



The following varieties have been distinguished, the zoisite being, perhaps, a separate species:—

(1.) *Zoisite* (Karsten, Werner, &c.), white, yellowish, or brownish-grey, chiefly in large imbedded crystals, or in foliated columnar masses. B.B. intumesces and forms a white or yellow porous mass, and on the edges fuses to a clear glass. With borax shows slight traces of iron; with cobalt solution becomes blue. Usually regarded as a lime-epidote, but rather characterised by the very small amount of peroxide of iron replacing the alumina. Analyses.

	Silica.	Alumina.	Lime.	Iron protox.	Mang. protox.	Magnesia.	Total.	
1	40·74	28·94	20·52	5·19 *a*	1·78	4·75	101·92	Geffken, Faltigel, Tyrol.
2	40·03	29·83	18·85	4·24	7·55	...	100·50	Do. Fichtelgebirge.
3	39·30	29·49	22·96	6·48	trace.	1·36 *b*	99·59	Thomson, Carinthia.
4	40·21	25·59	23·20	7·68	trace.	1·71 *b*	98·47	Do. Williamsburg, Mass.
5	40·00	26·46	20·66	6·33 *a*	...	3·60 *c*	98·55	Besnard, Grossarl, Salzburg.
6	40·57	32·07	20·82	4·60	...	1·22 *b*	99·88	M. Richter, Passeyer.

(*a*) Peroxide; (*b*) water; (*c*) + 1·50 potash.

Occurs imbedded in granite, diorite, or other crystalline rocks; in subordinate veins or beds with other minerals, as in gneiss on the Sau Alpe in Carinthia; rarely in vesicular cavities in porphyry, as in the Ural; also found in Connecticut and other parts of North America. No. 6 was considered spodumene, but is zoisite.

(2.) *Pistazite*, Werner; *Thallite*, Beudant; pistacio-green to blackish-green and black, also olive or siskin-green, yellow, or brown. Crystallized, or massive and imbedded in prismatic, granular, compact, or earthy aggregates, also in layers or crusts. B.B. fuses on

the edges, and then swells up into a dark-brown slag, sometimes magnetic. In borax forms a glass coloured by iron. It is considered an iron-epidote, much of the alumina being replaced by the peroxide of this metal. Analyses.

	Silica.	Alumina.	Lime.	Iron perox.	Magnesia.	Total.	
1	37·0	21·0	15·00	24·0 *a*	...	98·5	Vauquelin, Arendal.
2	36·14	22·24	22·86	14·29	2.38 *b*	100·03	Geffken, Do.
3	37·98	20·78	23·74	17·24	1·11	100·85	Rammelsberg, Do.
4	44·56	23·72	24·71	8·33	...	101·32	Do. Rothlaue, Bern, G. = 3·387.
5	40·62	29·18	22·67	6·19	0·73	99·81	Kühn, Zwiesel, Bavaria.
6	40·57	14·27	30·00	13·44	2·76	101·24	Do. Geier, Erzgebirge.
7	39·85	21·61	22·15	16·61	0·30	100·52	Do. Dauphiné.
8	38·64	21·98	21·95	17·42	0·27	100·26	Do. Penig, Saxony.
9	36·68	21·72	23·07	16·72	0·53	98·72	Do. Arendal.
10	38·89	18·85	16·00	16·34	6·10 *c*	98·57	Wagner, Ural (Puschkinite).

(*a*) + 1·5 manganese peroxide; (*b*) + 2·12 manganese protoxide; (*c*) + 0·26 manganese peroxide, 1·67 soda, and 0·46 lithia.

This is the most common variety of epidote, and occurs imbedded in many crystalline rocks, as granite, diorite, euphotide, greenstone, porphyry; also in druses or vesicular cavities in trap, and in veins or beds among the crystalline schists, especially with ores of iron, copper, and other metals. The finest crystals are found in the magnetic iron at Arendal; but others in the Ural, in Piemont (Mont Blanc), and other parts of the Alps; also in the Pyrenees, the Fichtelgebirge, the Harz, Finnland, Greenland, and North America. In Scotland it is common in Zetland in syenite; in gneiss in Sutherland; in trap in Mull and Skye; in quartz in Rona; in clay-slate in Arran; and in porphyry in the latter island and in Glencoe.

The *Puschkinite* (No. 10), from the Ural, of green, yellow, or red colours, G. = 3·066, was once considered green tourmaline, but is only epidote. The *Withamite*, found in porphyry in Glencoe, in minute bright red crystals, is also a variety. In transmitted light it appears carmine-red in one, pale straw-yellow in another direction, which are vertical to each other, and to the lengthened prism. The *Cummingtonite* from Massachusetts is also probably this variety of epidote.

(3.) *Manganese-epidote* (Phillips, Haüy), in which much of the alumina is replaced by manganese-peroxide, is of a dark violet-blue or reddish-black colour. Streak cherry-red. Forms columnar or prismatic aggregates. H. = 6·5; G. = 3·404. B.B. melts easily to a black glass; with borax shows reaction for manganese. Analyses.

	Silica.	Alumina.	Lime.	Mang. perox.	Mang. protox.	Iron perox.	Magnesia.	Total.	
1	36·87	11·76	22·78	18·25	...	10·33	..	99·99	Geffken.
2	38·47	17·65	21·65	14·08	...	6·60	1·82	100·27	Hartwall.
3	37·86	16·30	13·42	19·96	4·82	(7·41) *a*	...	99·17	Sobrero.

(*a*) Protoxide of iron + 0·40 tin and copper oxide.

Found only at St Marcel in Piemont, along with calc-spar, quartz, and hornblende (grammatite). Sobrero found tin oxide in many other epidotes, especially from Finnland.

(4.) *Thulite*, Brooke. Occurs massive or imbedded. Cleavable in two directions, inclined at 92° 30′. G. = 3·1 — 3·2. Colour, rose or peach-blossom red; translucent and vitreous. B.B. frothes, and intumesces to a white porous mass, but fuses only on the edges. Analyses.

	Silica.	Alumina.	Lime.	Iron perox.	Mang. perox.	Soda.	Water.	Cerium oxide.	Total.	
1	42·81	31·14	18·73	2·29	1·64	1·89	0·64	...	99·14	C. Gmelin.
2	46·10	...	12·50	5·45	...	8·00*a*	1·55	25·95	99·55	Thomson.

(*a*) Potash.

Gmelin's analysis agrees with the formula for epidote, when the iron is taken as the protoxide. Wöhler has examined the genuine mineral without finding any cerium. Occurs at Souland in Tellemark, Norway.

The *Buchlandite* of G. Rose, found in small black crystals with glassy felspar near Lake Laach, and in granite at Werchoturje, Siberia, is described by him as a pure iron epidote. The Bucklandite of Lévy from Arendal, opaque, blackish-brown, or black, and much resembling augite, seems a different mineral, but its composition is unknown.

149. AXINITE, *Hauy*, *Phillips*, *&c.*; Thumerstein, *Werner*; Prismatic-axinite, *Mohs*.

Triclinohedric; usually in very unsymmetrical crystals (figs. 137 and 138), where the inclination of *u* to P = 135° 10′, of *u* to *r* = 115° 17′, of *P* to *r* = 134° 40′. The crystals are attached singly, or united in druses. Also occurs massive in laminar or broadly-radiated aggregates. Cleavage, imperfect along a plane truncating the sharp edge between *P* and *u*, and forming an angle with *P* of 103° 5′. H. = 6·5 — 7; G. = 3 — 3·3. Transparent, or translucent

Fig. 137.

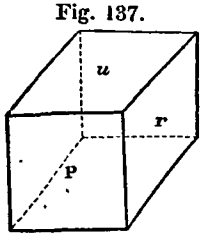
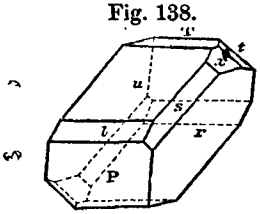


Fig. 138.



only on the edges. Lustre vitreous. Clove-brown, inclining to smoke-grey or plum-blue. Streak white. B.B. intumesces and fuses easily to a dark-green glass, becoming black in the ox. flame. With borax forms a glass coloured by iron, but changing to violet-blue in the outer flame, from the manganese. With fluor-spar and bisulphate of potash colours the flame green from boracic acid. Not soluble in hydrochloric acid till after ignition, when it gelatinizes. Analyses.

	Silica.	Boracic acid.	Alumina.	Iron perox	Mang. perox.	Magnesia.	Lime.	Total.	
1	45·00	2·00	19·00	12·25	9·00	0·25	12·50	100·00	Wiegmann, Treseburg.
2	43·47	...	16·30	10·25	2·74	1·55	19·90	...	Rammelsberg, Oisans (A).
3	43·63	5.61	15·63	9·45	3·05	1·70	20·67*b*	100·43	Do. Do. (B).
4	43·74	6·62*a*	15·66	11·94	1·37	1·77	18·90	100·00	Do. Treseburg, Harz.
5	43·72	5·81*a*	16·92	10·21	1·16	2·21	19·97	100·00	Do. Miask.

(*a*) With alkali and loss; (*b*) + 0·64 potash.

The composition, as these analyses show, is very complex. L. Gmelin assigns $4\,\dot{R}\,\ddot{S}i + 2\,\ddot{R}\,\ddot{S}i^2 + \dot{C}a^2\,\ddot{B}$, or a double salt of silica, combined with borate of lime. Rammelsberg, again, considers the boracic acid as isomorphous with silica, and gives $(\dot{C}a, \dot{M}g)^3\,(\ddot{S}i, \ddot{B})^2 + 2\,(\ddot{A}l, \ddot{F}e, \ddot{M}n)\,(\ddot{S}i, \ddot{B})$. In another experiment Rammelsberg found the boracic acid 3·40 per cent., and thinks the mean, or 4·5, nearest the true amount.

Haidinger describes this mineral as showing distinct trichroism, being cinnamon-brown in one direction, dark violet-blue in a second, and pale olive-green in a third. Riess and G. Rose found in it two pyroelectric axes, which do not pass through the centre, nor correspond with those of the crystal.

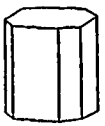
Axinite is not very abundant, and occurs chiefly in fissures, veins, or subordinate beds,—especially in granite, hornstone, diorite, gneiss, and in mica, hornblende, and clay-slate,—associated with quartz, felspar, epidote, chlorite, asbestus, &c. It is found rarely in mineral veins, as those of silver at Kongsberg in Norway; in beds with magnetic iron (Arendal, and Nordmark in Sweden), zinc-blende, copper pyrites, and other ores. The finest crystals are from Bourg d'Oisans in Dauphiné, and the Botallack mine in Cornwall. At the latter it also appears massive and compact, forming a peculiar rock with garnet and tourmaline. This variety, according to Turner (not confirmed by Rammelsberg), does not exhibit the reaction for boracic acid. The Pyrenees, Savoy, Tyrol, Thum in Saxony, the Ural, and Maine, North America, are other localities.

150. CYANITE, Kyanite, *Phillips, &c.*; Zianite, *Werner*; Disthene, *Haüy, &c.*; Prismatic Disthene-spar, *Mohs.*

Monoclinohedric; C. = 106° 15′. Generally in broad prismatic

crystals much lengthened along the orthodiagonal, and formed chiefly by $\infty P\infty$, 0P, and $P\infty$ ($0P : P\infty = 122° 20'$), the prisms often bounded by ($\infty P\infty$) (fig. 139). Macles are common, united by $\infty P\infty$. The crystals are imbedded singly. Also found in even, curved, radiated or confused columnar aggregates. Cleavage, orthodiagonal very perfect, basal less perfect. Brittle; H. = 5 — 7; G. = 3·5 — 3·7. Transparent to translucent only on the edges. Lustre vitreous, on $\infty P\infty$ pearly. Colourless, or coloured bluish-white, berlin and azure-blue, also grey, green, yellow, or red. Becomes electric by friction, and sometimes positive on the one, negative on the other side. Not affected by acids. B.B. infusible alone. With salt of phosphorus leaves silica; with cobalt solution becomes dark-blue. Chem. com. $\ddot{A}i\,\dot{S}i$, with 37·6 silica, and 62·4 alumina. Analyses.

Fig. 139.



	Silica.	Alumina.	Iron perox.	Total.	
1	43·0	55·5	0·5*a*	98·5	Klaproth, St Gotthardt.
2	34·33	64·89	...	99·22	Arfvedson, Do.
3	36·90	64·70	...	101·6	Do. Do.
4	36·4	63·2	...	100·2	Do. Röraas.
5	42·0	57·5	...	99·5	Vanuxem, St Gotthardt.
6	42·56	57·00	...	99·56	Do. Chesterfield Massachusetts.
7	36·67	63·11	1·19	100·97	Rosales, St Gotthardt.
8	37·36	62·09	0·71	100·16	Erdmann, Tyrol (G. = 3·661.)
9	34·40	61·66	0·52*b*	96·97	Do. Röraas (G. = 3·124.)
10	37·30	62·60	1·08	100·98	Jacobson, Greiner, Tyrol (G. = 3·678.)

(*a*) + trace of potash; (*b*) + 0·19 copper protoxide.

Cyanite occurs chiefly in mica and talc slates, but also in granite, gneiss, dolomite, and crystalline limestone. The finest crystals are found near St Gotthardt, and at the Greiner and Pfitsch in Tyrol. Some white or red varieties from the latter are named *Rhætizite*. Large crystals also occur at Pontivy in France, in Bohemia, and in South and North America. Fine blue lamellated varieties occur at Botriphny in Banffshire, and it has also been found in Zetland. Transparent blue cyanite is often polished and substituted for sapphire, but is easily known from its inferior hardness.

151. SILLIMANITE, *Bowen.*

Triclinohedric (according to Dana) with $\infty P' : \infty'P = 98°$, $P' : \infty P' = 105°$. Crystals long and slender; also fibrous, parallel, or slightly divergent. Cleavage, macrodiagonal highly perfect; H. = 7 — 7·5; G. = 3·2 — 3·26. Translucent; vitreous, inclining to pearly; greyish-brown, clove, or hair-brown. B.B. infusible alone; not affected by acids. Analyses, next page.

	Silica.	Alumina.	Iron perox.	Magnesia.	Watr.	Total.	
1	42·67	54·11	2 00	...	0·51	99·29	Bowen.
2	38·67	35·11	7·22	18·51*a*	...	99·51	Muir.
3	36·75	58·94	0·99	...	...	96·68	Connel.
4	37·70	62·75	2·29	...	...	102·74	Norton.
5	37·36	58·62	2·17	0·40	0·43	98·98	Staaf.
6	45·65	49·50	4·10*b*	...	...	99·25	Thomson (1845).
7	42·60	54·90	1·10*c*	0·40	...	99·31	Hayes.
8	47·44	52·54	...	...	...	99·98	Komonen (Xenolite).
9	40·79	53·06	...	0·88	4·63	99·36	Hess (Worthite), m. of 2.

(*a*) Zirconia; (*b*) protoxide; (*c*) with protoxide of manganese, + 0·31 lime.

The zirconia found by Muir has not been again observed. The other analyses also differ considerably. Nos. 1–7 give nearly $\ddot{A}i^4\,\ddot{s}i^9$; No. 6 $\ddot{A}i^2\,\ddot{s}i$, agreeing with Xenolite, No. 8; and No. 5 $\ddot{A}i\,\ddot{s}i$, or the same with cyanite; whilst the loss in No. 3 and the excess in No. 4, render them uncertain. It is thus doubtful whether this mineral is distinct from cyanite, to which its angles approach very near. It is found in quarz in gneiss at Chester, and near Norwich in Connecticut, and in long white or wine-yellow prisms at Tvedestrand in Norway; also with magnetic iron near Yorktown in New York. The *Xenolite*, found in loose fragments at Peterhoff in Finnland, and the Wörthite, opaque, pearly, and white, from loose blocks near St Petersburg, seem nearly related to this mineral, or cyanite.

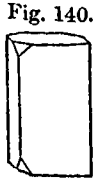
152. Bamlite, *Erdmann.*

Monoclinohedric? in oblique four-sided prisms, usually strongly striated; also massive and radiated fibrous. Fracture uneven and splintery; H. = 6 — 7; G. = 2·98. Translucent, colour greyish-white. B.B. infusible. Becomes blue with cobalt solution. Chem. com. $\ddot{A}i^4\,\ddot{s}i^9$, with 57·6 silica, and 42·4 alumina. Erdmann found 56·90 silica, 40·73 alumina, 1·04 iron peroxide, 1·04 lime, and trace of fluorine (= 99·71.) It occurs in quartz masses in gneiss at Brakka in Bamle near Brevig in Norway.

153. Andalusite, *Lametherie, Werner, Hauy, Phillips, &c.;* Prismatic Andalusite, *Mohs.*

Rhombic; ∞P 90° 50′, $\breve{P}\infty$ 109° 4′; usual combinations, ∞P. 0P, or this with $\breve{P}\infty$ (fig. 140). The crystals are prismatic, often large, and attached or imbedded. Also forms diverging, columnar, or granular aggregates. Cleavage, prismatic along ∞P, rather indistinct; traces along $\infty\breve{P}\infty$, $\infty\bar{P}\infty$ and $\bar{P}\infty$. Fracture uneven, splintery; H. = 7 — 7·5; G. = 3·1 — 3·3. Translucent or only on the edges; rarely transparent, and then shows distinct tri-

Fig. 140.



chroism. Lustre vitreous. Always coloured, grey to green, flesh or peach-blossom-red, violet-blue or reddish-brown. B.B. infusible alone, with borax forms with difficulty a clear glass. In powder becomes blue with cobalt solution. Not affected by acids. Chem. com. $\ddot{A}l^8\,\ddot{S}i^9$, with 40·4 silica, and 59·6 alumina. Analyses.

	Silica.	Alumina.	Iron perox.	Mang. perox.	Lime.	Magnesia.	Total.	
1	38	52	2	...	...	...*a*	100	Vauquelin, Spain.
2	36·5	60·5	4·0	..	...	...	101·0	Bucholz, Herzogau.
3	40·17	58·62	...	0·51	0·28	...	99 58	Bunsen, Lisens.
4	35·30	60·20	1·32*b*	...	...	1·00*c*	99·85	Thomson, Tyrol.
5	37·65	59·67	1·87	...	0·58	0·38	100·35	Svanberg, Fahlun.
6	37·51	60·01	1·49	...	0·48	0·46	99·95	Kersten, Triebischthal (G. = 3·152).
7	39·99	58·66	0·72	0·23	...	...	100 14	Erdmann, Lisens.
8	39·09	58·56	...	0·53	0·21	...*d*	99·38	Bunsen, Lancaster Mass.
9	46·0	50·0	2·5	...	...	...*e*	100·00	Brandes, Faltigel, Tyrol.
10	46·40	52·92	...	...	...	...	99·32	Thomson, Chester, Pens.
11	40·08	53·88	0·74	...	...	...	99 67	Erdmann, Do. (G. = 3·239).
12	38·00	58·25	0·75	...	...	...	97·00	Chevenix, Carnatic.

(*a*) + 8 potash; (*b*) protoxide; (*c*) + 2·03 water; (*d*) + 0·99 volatile; (*e*) + 1·5 potash.

Nos. 2, 4, 5, 6 nearly agree in composition with cyanite, and are perhaps pseudomorphs of that mineral. In Nos. 9, 10 Rammelsberg supposes the silica to contain some undecomposed mineral.

Andalusite occurs chiefly imbedded in mica slate, or in druses in other crystalline rocks. It was first found in Andalusia, but since in fine varieties at Lisens in the Tyrol, Penig in Saxony, Westford Mass., and Litchfield Connecticut. It also occurs in gneiss at Botriphny in Banffshire, and in mica slate at Killiney Bay in Wicklow. The finely fibrous varieties (Nos. 9–12) have been named Bucholzite or fibrolite, but are identical in composition.

Chiastolite (Phillips; *Hohlspath*, Werner) No. 8, has been considered a distinct species. It is of a dirty or pale-grey, yellow, or red colour, with dull vitreous lustre. It occurs imbedded in clayslate, especially near granite, and often appears like four crystals separated by a black cross of the dark slate (fig. 141). Mohs endeavours to explain this mosaic formation, as it was named by Hauy, from a macle, but there are still some difficulties attached to this theory. Thus in some the black colour is destroyed by heat, in others it is not, continuous, and in others again pervades almost the entire mass. In some, too, the light part seems composed of irregular fragments. It is found in the Fichtelgebirge, in Brittany, the Pyrenees, in the Sierra Morena, and at St Jago di Compostello in Spain, where it is cut into rosaries or amulets, and sold to the pilgrims. It is abundant at Lancaster and Sterling in Massachusetts. Also common at Wolfscrag near Keswick, and on Skiddaw in Cumberland; near Balahulish in Argyleshire; and in Wicklow in Ireland.

Fig. 141.

154. STAUROLITE, *Karsten*, *Phillips*; Staurotide, *Hauy*; Grenatite, *Jameson*; Prismatoidal-garnet, *Mohs*.

Rhombic; ∞P 29° 20′, P̄∞ 69° 16′, common combinations ∞P (*M*) . ∞P̆∞ (*o*) . 0P (*p*) and ∞P̆∞ . ∞P . P̄∞; the crystals short and thick, or long and broad columnar; surface often rough or corroded. Twin crystals very common, with chief axes intersecting, either almost at right angles, (fig. 142), or at nearly 60° (fig. 143). Cleavage, brachydiagonal perfect, traces along ∞P. Fracture conchoidal, or uneven and splintery. H. = 7 — 7·5; G. = 3·5 — 3·8. Translucent or opaque. Lustre vitreous, inclining to resinous. Colour reddish to blackish-brown; streak white. B.B. infusible

Fig. 142.

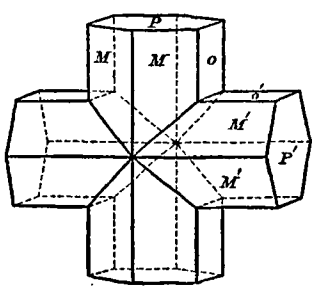
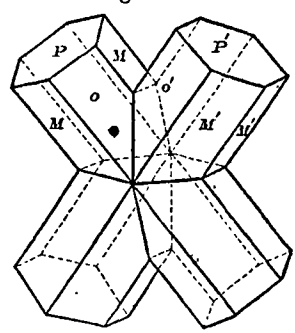


Fig. 143.



alone; in borax with difficulty to a dark green glass; in soda with effervescence to a yellow slag. Not affected by hydrochloric acid, and only partially by sulphuric. Analyses.

	Silica.	Alumina.	Iron peroxide	Magnesia.	Manganese.	Total.	
1	30·31	46·80	18·08	2·16	...*a*	97·48	Jacobson, St Gotthardt (*G.* = 3·737 solid to
2	30·91	48·68	15·37	1·33	1·19*b*	97·48	Do. Do. [3·744 in powder.)
3	29·72	54·72	15·69	1·85	...	101·98	Do. Do.
4	29·13	52·01	17·58	1·28	...	100·00	Do. Do.
5	28·47	53·34	17·41	0·72	0·31*c*	100·25	Marignac, Do.
6	33·22	47·58	16·58	1·83	...	99·20	Jacobson, Airola, Do. (*G.* = 3·66 — 3·73.)
7	39·77	44·55	15·43	0·16	0·13*d*	100·04	Do. Brittany, (*G.* = 3·527 — 3·529.)
8	38·51	46·70	14·83	2·46	...	102·49	Do. Polewskoi, Ural, (*G.* = 3·547 — 3·588.)

(*a*) + 0·13 lime; (*b*) protoxide; (*c*) peroxide; (*d*) proto-peroxide.

Nos. 6, 7, 8 are means of two trials agreeing closely. These analyses do not lead to any common formula, and the older ones are still more discordant. The St Gotthardt variety gives nearly $\ddot{R}^3\,\dot{S}i^2$; that from Airolo, $\ddot{R}\,\dot{S}i$, or the formula of cyanite; and those from

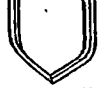
Brittany and the Ural, $\ddot{R}^5$ $\dot{S}i^6$. But, as Rammelsberg remarks, this difference of composition in bodies with the same form of crystallization, is difficult to be received; and hence, he suggests, that the silica is isomorphous with the bases $\ddot{R}$ (= $\ddot{A}i$ and Fe.) Perhaps this is also the case in cyanite and andalusite, which may explain the variations in their composition. The specific gravity decreases with the amount of silica.

It occurs imbedded in mica, talc, and clay slate, more rarely in gneiss. Fine crystals are found at St Gotthardt and the Greiner in Tyrol along with cyanite. It is sometimes curiously combined with the latter, the two minerals presenting themselves in continuous position, as if forming one and the same crystal. It is also common in many parts of the Pyrenees, in Spain, Bohemia, the Ural, and in North America. In Scotland it occurs in Aberdeenshire and the Hebrides.

155. DIASPORE, *Hauy*, *Werner*, *Phillips*; Eutomous Disthene-spar, *Mohs*.

Rhombic; broad indistinct prisms, formed chiefly by $\infty\breve{P}\infty$, along with ∞P 130°, and $\infty\breve{P}3$, and bounded on the ends by the curved faces of the fundamental form P (fig. 144). Usually massive in thin foliated or broad radiated aggregates. Cleavage brachydiagonal highly perfect; very brittle; H. = 6; G. = 3·3 — 3·4. Transparent or translucent; lustre pearly on $\infty\breve{P}\infty$; colourless, but generally yellowish or greenish-white, also violet-blue, and often appears yellowish-brown from hydrated peroxide of iron; insoluble in acids. B.B. decrepitates into small white scales, but is infusible alone; fusible in borax, and with solution of cobalt becomes blue. The diaspore from Kosoibrod does not decrepitate, but yields much water, and becomes brown; and after ignition is soluble in warm sulphuric acid. Chem. com. $\ddot{A}i\,\dot{H}$ = 85 alumina and 15 water. Analyses.

Fig. 144.



	Alumina.	Watr.	Iron perox.	Silica.	Lime.	Total.	
1	85·52	14·48	...	...	...	100·00	Hess, Miask (m. of 2).
2	78·93	15·13	0·52	1·39	1·98	97 95	Dufrénoy, Broddbo.
3	74·66	14·58	4·51	2·90	1·64	98·29	Do. Katharinenburg.
4	79·91	14·90	...	...	...*a*	100·61	Damour, Siberia.
5	85·13	15·00	...	...	...	100·13	Lowe, Schemnitz (G.=3.303).

(*a*) + 5·80 remainder.

Rare; but found in veins with brown iron ore in chlorite slate in the marble quarries near Kosoibrod and Gornoschit in the Ural; and in veins between dolomite and limestone near porphyry at Schemnitz;

also at Broddbo near Fahlun. The specimens from Schemnitz show a beautiful trichroism, especially in polarized light, appearing violet-blue in one direction, reddish plum-blue in another, and pale asparagus-green in a third.

156. HYDRARGILLITE, *G. Rose.*

Hexagonal, in very small crystals of the form cf 0P . ∞P . ∞P2, or in granular scaly masses. Cleavage, basal very perfect; H = 2·5 — 3; G. = 2·3 — 2·39. Translucent; lustre pearly on 0P, otherwise vitreous; colourless or reddish-white; slowly soluble in warm acids; in closed tube yields water. B.B. exfoliates, and gives out a strong light, but is infusible. Becomes blue with cobalt solution. Found in the talc slates of Schischimskaja Gora near Slatoust in the Ural.

GIBBSITE, *Torrey, Phillips, Mohs;* Gipsite, *Beudant.*—Stalactytic, or botryoidal masses, with thin, radiated, prismatic texture, H. = 3 — 3·5; G. = 2·4. Slightly translucent; dull; dirty-greenish or greyish-white; in closed tube yields much water. B.B. infusible, but becomes fine blue with solution of cobalt; soluble in acids. Found in a vein of brown iron ore at Richmond, Massachusets. Analyses.

	Alumina.	Watr.	Silica.	Iron perox.	Phosphoric acid.	Total.	
1	64·8	34·7	...	...		99·5	Torrey, Richmond.
2	54 91	33·60	8·73	3·23	...	101·16	Thomson, Do.
3	64·03	34·54	...	...	1·43	100	Hermann, Ural (G. = 2·387).
4	26·66	35·72	...	...	37·62	100	Do. Richmond,
5	65·6	34·4	...	..	...	100	v. Kobell, Villa Ricca.

Hermann's analysis of the hydrargillite, No. 3, agrees, except in the small amount of phosphoric acid, with Torrey's of the gibbsite, and gives the formula $\ddot{A}\dot{l}\,\dot{H}^3$, with 65·5 alumina, and 34·5 water. His analysis of the latter, No. 4, gives a very different result, or $\ddot{A}\dot{l}\,\dddot{P} + 8\,\dot{H}$. If this is the true gibbsite, it should retain that name, and have a place in the system near wavellite. No. 5, the so-called wavellite from Villa Ricca, Brazil, is a true hydrargillite.

157. PERICLASE; PERIKLAS, *Scacchi.*

Tesseral, as yet only in octahedrons; cleavage, hexahedral perfect; H. = 6; G. = 3·75. Transparent; lustre vitreous; colour dark-green. B.B. infusible; powder soluble in acids. Chem. com. magnesia, partly replaced by protoxide of iron. Analyses, next page.

	Magnesia.	Iron prot.	Insoluble.	Total.	
1	89·04	8·56	...	97·60	Scacchi.
2	92·57	6·22	0·86	99·65	Damour.
3	91·18	5·67	2·10	96·85	Do.

In the first analysis the loss was probably magnesia. Damour determined the iron to be the protoxide. It is found at Monte Somma near Naples.

158. GLAUCOPHANE, *Hausmann.*

Rhombic or monoclinohedric, but only found in indistinct, thin prismatic crystals, or massive and granular. Cleavage, prismatic along ∞P distinct. Fracture conchoidal, H. = 5·5; G. = 3·108. Translucent or opaque; vitreous or pearly on the cleavage planes; and greyish, indigo or lavender-blue, or bluish-black. Slightly magnetic. B.B. becomes yellowish-brown, and fuses readily to an olive-green glass. Partly soluble in acids. Chem. com. 2 $\ddot{A}i\,\dot{S}i^3$ + 9 $\dot{R}\,\dot{S}i$, or by Schnedermann's analysis, 56·49 silica, 12·23 alumina, 10·91 iron protoxide, 7·97 magnesia, 2·25 lime, and 9·28 soda, with traces of potash (= 99·63). It occurs in mica-slate in the Island of Syra, with garnet, hornblende, and chlorite. The characters of this species are still uncertain, and it is placed here only provisionally. The following minerals, if true species, are nearly connected with it.

WICHTYNE, *Laurent.* Massive, with traces of cleavage probably along a rhombic prism; G. = 3·03 H. scratches glass. Lustre dull, colour black. B.B. fuses to a black enamel. Not affected by acids. Chem. com. $\ddot{A}i\,\dot{S}i^3$ + 3 $\dot{R}\,\dot{S}i$, or by Laurent's analysis, 56·3 silica, 13·3 alumina, 13·0 iron protoxide, 4·0 iron peroxide, 3·0 magnesia, 6·0 lime, and 3·5 soda (= 99·1). Found at Wichtis in Finnland, and hence Hausmann changes the name to Wichtisite.

VIOLAN, *Breithaupt.* Rhombic? but only massive with cleavage along a slightly oblique rhombic prism; H. = 5 — 6; G. = 3·233. Opaque, resinous, dark-violet-blue, with bluish-white streak. B.B. fuses easily to a clear glass. With borax in the ox. flame forms a brownish-yellow glass, violet-red when cold; in red. flame a yellow glass, colourless when cold. Chem. com. according to Plattner, essentially silica, alumina, magnesia, lime, natron, iron, and manganese. Found with the manganese-epidote at St Marcel in Piemont.

BOLTONITE, *Shepard;* Silicate of magnesia, *Thomson.* Massive and coarse granular. Cleavage in one direction perfect, in two others oblique, imperfect; H. = 5; G. = 2·8 — 2·9. Translucent, yellowish-grey to wax-yellow. B.B. infusible. Chem. com. perhaps $(\dot{M}g, \dot{F}e)\,(\ddot{S}i, \ddot{A}i)$, or by Thomson's analysis, 56·64 silica, 36·52 mag-

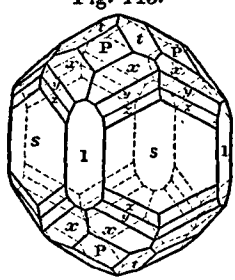
nesia, 6·07 alumina, and 2·46 iron protoxide (= 101·69). Found in a white limestone at Bolton, and in other places in Massachusetts and Connecticut.

XI Family.— Gems.

159. Zircon, *Hauy, Phillips;* Zirkon, *Werner;* Pyramidal Zircon, *Mohs.*

Tetragonal; P 84° 20′, most frequent combinations ∞P . P, often with 3P3; also ∞P∞ . P (like fig. 123, p. 168), and P . ∞P∞ . 2P . 3P . ∞P. In fig. 145 still more forms are seen, or ∞P∞ (*s*) . ∞P (*l*) . P (*P*) . 3P3 (*x*) . P∞ (*t*) . 4P4 (*y*) . 5P5 (*z*). Occurs in imbedded crystals, chiefly prismatic or pyramidal; and in rounded grains. Cleavage pyramidal along P, and prismatic along ∞P, both rather imperfect. Fracture conchoidal or uneven; H. = 7·5; G. = 4 — 4·7. Transparent to opaque; lustre vitreous, often adamantine, Colourless, rarely white, generally grey, yellow, green, or frequently red and brown. B.B. loses its colour, but is infusible alone or with salt of phosphorus, slowly in borax to a clear glass. Not affected by any acid, not even the hydrofluoric, except concentrated sulphuric acid, which partially decomposes it after long digestion. Chem. com. $\dot{Z}r^2\ddot{S}i$, or 66·23 zirconia, and 33·77 silica. Analyses.

Fig. 145.



	Silica.	Zirconia.	Iron perox.	Total.	
1	26·5	69·0	0·5	96·0	Klaproth, Zircon, from Ceylon.
2	25·0	70·0	0·5	95·5	Do. Hyacinth, Do.
3	32·5	64·5	1·5	98·5	Do. Zircon, Northern Circars.
4	33	65	1	99	Do. Do. Fredriksvärn, Norway.
5	34·00	64·00	0·25	98·25	John, Do. Do.
6	32·6	64·5	2·0	99·1	Vauquelin, Hyacinth, Ceylon.
7	33·48	67·16	...	100·64	Berzelius, Do. Expailly, Auvergne.
8	32·08	67·07	...	99·15	Vaxuxem, Zircon, North Carolina.
9	35·26	63·33	0·79*a*	99 74	Gibbs, Litchfield Maine, (G. = 4·7).

(*a*) + 0·36 undecomposed mineral.

In 1789 Klaproth discovered the earth named zirconia in this mineral, and showed its identity with the Hyacinth. Thomson states that it contains alumina, and Svanberg finds that the zirconia is mixed in various proportions with Noria, which may explain the difference

in hardness and specific gravity in different specimens. The Stockholm variety has G. = 4·03 and lower hardness than others. The Norwegian zircon seems to contain most noria.

Zircon is most abundant in the syenite of southern Norway, and in very fine crystals in the miascite of the Ilmen mountains in the Ural. It is also found in the iron mines at Arendal; in granite and gneiss near Stockholm in Sweden, in Carinthia at the Sau Alpe, in Tyrol at Pfitsch, and at Baltimore in New Jersey, and other parts of North America. In Scotland at Scalpay in Harris, and in the granite of Criffel in Kirkcudbrightshire. It occurs in basalt at Unkel, and in the Siebengebirge on the Rhine, and near Expailly in France; in amygdaloid near Vicenza; in ejected blocks at Lake Laach and Vesuvius. It is found in grains or loose crystals in Ceylon, and in the gold sands of Ohlapian in Siebenburg, and of the Ural.

The colourless varieties are often sold for diamonds. The more brilliantly coloured are named hyacinth, but are rarely of large size, and many hyacinths are garnets known by their inferior gravity. The hyacinthus of the ancients was a different stone, and the lyncurius seems rather to have been the zircon.

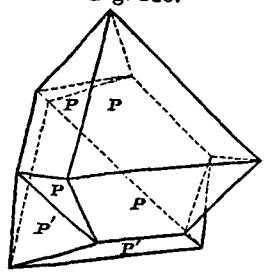
160. Malakon, *Scheerer.*

Tetragonal; P 82°; occurs in small imbedded crystals of the combination ∞P∞ . P . ∞P, like zircon. Cleavage unknown; fracture conchoidal; H. = 6; G. = 3·9 — 3·913. Opaque, or in splinters yellowish translucent; lustre resinous on fracture, vitreous on the crystal faces. Colour internally bluish-white, but on the surface mostly coloured brownish, reddish, yellowish, or blackish. B.B. is infusible, but ignites slightly on heating, loses 3·027 per cent. water, and the specific gravity increases from 3·9 to 4·2. In fine powder decomposed by digestion in sulphuric acid before ignition. In other respects acts like zircon. Scheerer found in his analysis 31·31 silica, 63·40 zirconia, 0·41 iron protoxide, 0·34 yttria, 0·39 lime, 0·11 magnesia, 3·03 water (= 98·99). Its composition is thus that of zircon with 3 per cent. water; the latter perhaps not essential. It seems a peculiar modification of zirconia, which changes by ignition into the usual variety. It is found at Hitterö in Norway.

161. Spinel, *Werner, Hauy, Phillips;* Dodecahedral Corundum, *Mohs.*

Tesseral; common forms O, ∞O, and 3O3; the octahedron often alone, and generally predominating. Macles united by a face of O, and individually much shortened (fig. 146). Occurs in single im-

Fig. 146.



bedded or attached crystals, rarely in druses; also in loose grains or fragments. Cleavage, octahedral imperfect; fracture conchoidal. H. = 8; G. = 3·4 — 3·8. Transparent to opaque; lustre vitreous. Colourless; but generally coloured reddish-white, rose, carmine, crimson, blood, or hyacinth red; bluish-white, smalt, indigo, or violet-blue; bluish-black, grass-green, and greenish-black. Streak white. B.B. infusible and unchanged, except the red variety from Ceylon, which, when cooling, becomes green, then colourless, and again red. With borax or salt of phosphorus yields a clear bead, slightly coloured by iron or chrome. Chem. com. $\dot{M}g\,\ddot{A}i$ = 72 alumina, and 28 magnesia; but part of the magnesia replaced by iron protoxide, part of the alumina by iron peroxide, and the red varieties often contain chrome. Analyses.

	Silica.	Alumina.	Magnesia.	Iron protox.	Chrome.	Total.	
1	5·48	72·25	14·63	4·26	...	96·62	Berzelius (1817), Aker, blue S.
2	2·25	69·94	25·72	3·49	...	100·47	Abich (1830), Do.
3	...	86·00	8·50	...	5·25 *a*	99·75	Vauquelin, Ceylon, red S.
4	2·02	69·01	26·21	0·71	1·10 *b*	99·05	Abich, Do. do.
5	5·62	73·31	13·63	trace	... *c*	99·98	Thomson, Franklin, N. J., green S.
6	5·60	61·79	17·87	10·56	... *d*	99·60	Do. Amity, N. Y., do.
7	5·09	55·17	17·65	18·33	... *e*	98·95	Scheerer, Arendal.
8	3·15	57·20	18·24	20·51	...	99·10	C. Gmelin, Ceylon (Ceylonite).
9	2·50	65·27	17·58	13·97	...	99·32	Abich, Ural.
10	1·23	66·69	23·61	8·07	...	99·80	Do. Monzoni, Fassathal.
11	2·38	67·46	25·94	5·06	...	100·84	Do. Vesuvius.
12	1·79	59·66	17·70	19·29	...	99·17	Do. Iserweise.
13	1·83	62·34	24·87	3·87	... *f*	99·56	Do. Monte Somma.
14	...	61·17	2·92	35·67	...	99·76	Quadrat, Bonsperg, Bohemia.

(*a*) Chromic acid; (*b*) chrome oxide; (*c*) + 7·42 lime; (*d*) + 2·80 lime and 0·98 water; (*e*) + 2·71 protoxide of manganese; (*f*) + 6·15 peroxide of iron.

The older analyses are imperfect, partly from the hardness of the mineral, partly from its resistance to reagents. Abich's analyses were performed by fusing the finely-pounded mineral with carbonate of barytes.

The Spinel or Spinel-ruby, comprising the red and violet varieties, Nos. 1–6, occurs chiefly in Ceylon, Ava, and other parts of the East, in loose grains in the rivers. Its original locality, said to be in granite, gneiss, or dolomite, is unknown. A blue variety is found in marble at Aker iron works in Södermanland in Sweden. This has been named *Saphirine* (Giesecke, Phillips, Mohs), along with a similar mineral from Fiskenaes in Greenland, in which Stromeyer found 14½ per cent. silica. The dark varieties, Nos. 7–13, with G. above 3·65,

are named *Pleonaste* (Hauy, Phillips), and are found either loose near Candy in Ceylon (*Candite*, or *Zeilanite*, Werner); or in perfect crystals, in dolomite on Monte Somma, at Monzoni, in calc-spar in the iron ore at Arendal, in several places in Germany, in the Ural near Kyschtimsk, and at Warwick in New York. When large and highly-coloured, the spinel is prized as an ornamental stone. The rose-red are named Balas ruby; the yellow or orange-red, Rubicelle; and the violet, Almandine-ruby. No. 14 is the *Hercinite* of Zippe, a black spinel found in Bohemia in alluvium, G. = 3·91 — 3·95. On ignition the leek-green powder becomes brick-red, and the weight increases 3·2 per cent. from the higher oxidation of the iron.

The *Chlorospinel* (G. Rose), from the talc-slate of Slatoust in the Ural, is a grass-green variety, with a yellowish-white streak. H. = 8; G. = 3·591 — 3·594. It becomes brownish-green when heated, and with borax fuses easily to a light-green glass, colourless when cold. The crystals are 1—3 lines in diameter, and are associated with magnetic iron ore and yellow garnet. Analyses.

	Alumina.	Iron perox.	Magnesia.	Lime.	Copper protox.	Total.	
1	64·13	8·70	26·77	0·27	0·27	100·14	H. Rose.
2	57·34	14·77	27·49	...	0·62	100·22	Do.

162. AUTOMALITE, *Ekeberg, Werner, Phillips;* Gahnite, *Hausmann, Beudant;* Octahedral corundum, *Mohs.*

Tesseral; O sometimes simple, sometimes as a macle. Cleavage, octahedral perfect. Brittle, with conchoidal or splintery fracture. H. = 8; G. = 4·1 — 4·3 (4·3 — 4·589, *G. Rose*). Opaque or translucent on the edges. Lustre vitreous, inclining to resinous. Dark leek-green to blackish-green and blue. Streak grey. B.B. unchanged alone, and nearly so with borax and salt of phosphorus; in fine powder with soda in the red. flame leaves traces of zinc oxide on the charcoal. Not affected by acids or alkalis. Chem. com. $\dot{Z}n\ddot{A}i$, with 56 alumina, and 44 zinc oxide, but the latter partly replaced by protoxide of iron or magnesia. H. Rose thinks the silica in it and other spinel minerals accidental. Analyses.

	Alumina.	Zinc oxide.	Iron protox.	Magnesia.	Silica.	Manganese.	Total.	
1	60·24	24·25	9·25 *a*	...	4·75	trace *b*	98·25	Ekeberg, Fahlun.
2	55·14	30·02	5·85	5·25	3·84	trace	100·10	Abich, Do.
3	57·09	34·80	4·55	2·22	1·22	traces *c*	99·38	Do. North America.

(*a*) Peroxide; (*b*) with lime; (*c*) with cadmium.

Found crystallized in talc-slate along with zinc-blende and galena near Fahlun, also at Broddbo. Compact near Säther and Garpenberg in Sweden. Also at Haddam in Connecticut, with garnet and chrysoberyl; and at Franklin in New Jersey.

A black spinel or pleonaste, from Bodenmais in Bavaria, is distinguished by Breithaupt. It has G. = 4·89; and, according to Plattner, B.B. shows with fluxes reaction for iron, with cobalt solution for alumina, and with soda and borax a deposit of zinc oxide.

163. CORUNDUM, *Phillips, &c.*; Corindon, Télésie, *Hauy*; Korund, Demantspath, *Werner*; Rhombohedral Corundum, *Mohs.*

Rhombohedric, isomorphous with peroxide of iron and chrome; R 86° 4'. The forms that generally predominate are ∞P2 (*s*), 0R (*o*), R (*P*); and several hexagonal pyramids of the second kind, especially ⅓P2, ½P2, and 4P2. The general character of the combinations is pyramidal (fig. 147), prismatic (fig. 148), or rhombohedral.

Fig. 147.

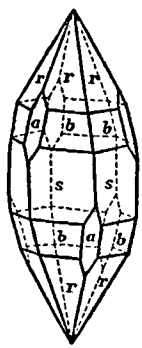
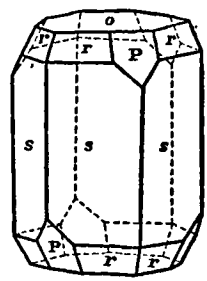


Fig. 148.



It occurs in crystals imbedded or loose; also in coarse or fine granular masses. Macles common, united by a face of R, and often repeated in a lamellar form. Cleavage rhombohedral along R, or basal in very various degrees of perfection. Fracture conchoidal, to uneven and splintery; extremely tough, and difficultly frangible. H. = 9; G. = 3·9 — 4. Transparent or translucent. Lustre vitreous, sometimes pearly on 0R. Colourless and white, but generally blue, red, yellow, brown, or grey. B.B. unchanged alone; the fine powder becomes blue with cobalt solution; with borax and salt of phosphorus fuses difficultly to a clear glass. Chem. com. alumina with a minute proportion of peroxide of iron or other colouring matter. H. Rose

has shown that the silica found by Klaproth and others was derived from the mortar.

Three varieties are distinguished in this mineral:—(1.) *Sapphire*, highly transparent varieties, with very imperfect cleavage and conchoidal fracture; those of fine red colours being often named oriental rubies and the blue salamstein. (2.) *Corundum*, in rough crystals or masses with distinct cleavage, less transparent and duller colours. Some, named *astéria* or star sapphire, when cut *en cabochon* perpendicular to the axis of the prism show a bright opalescent star of six rays corresponding to the other axes. The adamantine spar is a variety with very distinct cleavage, hair-brown colour, and adamantine lustre. (3.) *Emery* (*Schmirgel*, Werner), is the compact, dimly translucent varieties of grey or indigo-blue colours.

The finest sapphires come from the East, especially Ceylon, where it occurs loose or imbedded in gneiss; Ava and Pegu. Smaller crystals have been found loose near Bilin and Merowitz in Bohemia, near Hohenstein in Saxony, and in the sand of the Expailly river near Le Puy in Auvergne. It occurs imbedded in granite in the Chamouni valley, and near Newton in New Jersey; in basalt on the Rhine; and in the millstone lava of Niedermenning near Lake Laach. The oriental ruby when perfect is valued at about half the price of the diamond, but does not occur of such size; though Allan mentions one three inches long; and another valued at L.3000. The corundum occurs in granite rocks in the Carnatic, Malabar, Ava, and near Canton in China, of a red or blue colour in the dolomite of Campo Longo near St Gotthardt, and in large crystals in granite in Piemont. The adamantine spar is found at Gellivara in Lapland imbedded in magnetic iron; also in the Ural, in Malabar, and in several parts of North America. Emery is chiefly brought from Naxos and other of the Greek islands, but also occurs in large boulders near Smyrna, in talc slate on the Ochsenkopf near Schwarzenberg in Saxony; in Spain and in Greenland.

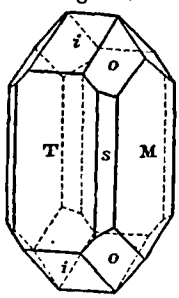
Besides its value as an ornamental stone, the sapphire has been used for lenses for microscopes, for jewelling watches, and when bored for drawing fine gold and silver wire. Emery is employed as a polishing material, the blue coloured being the best, that from Spain the most common, but frequently mixed with magnetic iron and quartz. Some varieties contain none of the real emery, but are mere mixtures of quartz, garnet, iron oxide, and similar substances.

The sapphirus of the Greeks and Romans seems to have been the Lapis-lazuli, and not this stone. The Astrios of Pliny was, however, the star sapphire; and the Σμύρις probably the emery.

164. CHRYSOBERYL, *Phillips, Hausmann;* Cymophane, *Haüy;* Prismatic Corundum, *Mohs, Jameson.*

Rhombic; P with polar edges 86° 16′ and 139° 53′; $\breve{P}\infty$ 119° 46′, $\infty\breve{P}3$ 109° 20′; common combinations $\infty\breve{P}\infty$ (*M*). $\infty\breve{P}\infty$ (*T*). $\breve{P}\infty$ (*i*), or this with ∞P3 (*s*), and also with P (*o*), fig. 149, and other forms. The crystals appear short and broadly columnar, or thick tabular with vertical striæ. Macles very common, united by a face of $\breve{P}\infty$, and often repeated. Crystals imbedded or loose; also in rounded fragments and grains. Cleavage, brachydiagonal imperfect; macrodiagonal more indistinct. Fracture conchoidal. H. = 8·5; G. = 3·68 — 3·8. Transparent or translucent. Lustre vitreous, sometimes resinous. Colour greenish-white, leek-green, olive-green, and greenish-grey; sometimes with a bluish opalescence, or beautiful dichroism. B.B. infusible alone; with borax slowly and with difficulty to a clear glass. Not affected by acids. Chem. com. $\dot{G}\,\ddot{A}\dot{i}$ or 80·25 alumina and 19·75 glucina.

Fig. 149.



	Alumina.	Glucina.	Silica.	Iron prot.	Titan. acid.	Loss by heat.	Total.	
1	68·67	16·00	6·00	4·73	2·67	0·67	98·74	Seybert, Brazil.
2	73·60	15·80	4·00	3·38	1·00	0·40	98·18	Do. Connecticut.
3	76·75	17·79	...	4·49	...	0·48	99·51	Thomson, Do.
4	78·10	17·94	...	4·47	...	...	100·51	Awdejew, Brazil, G. = 3·7337.
5	78·92	18·02	...	3·12	...*a*	...	100·71	Do. Ural, G. = 3·689.
6	76·99	16·88	...	4·13*b*	...	...	100·00	Damour, Connecticut, (m. of 3.)

(*a*) + 0·36 chrome oxide, and 0·29 copper and lead oxide; (*b*) peroxide.

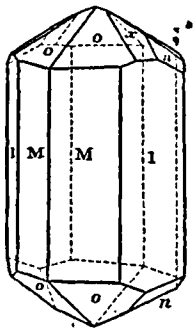
Seybert first observed glucina in this mineral, whilst Thomson's and Awdejew's experiments prove the silica to be only incidental. The peroxide of iron replaces part of the alumina, the protoxide of the glucina.

Occurs chiefly in loose grains in the sand of rivers with other gems in Brazil, Ceylon, and other parts of India. At Haddam in Connecticut, and Saratoga in New York, it is found in granite with tourmaline, garnet and beryl. Fine large crystals of a green colour, but hyacinth-red in one direction, are found with emerald in mica slate on the Takowaja, 180 versts east of Katharinenburg. In this mineral Sir D. Brewster observed fluids in cavities so minute, that 30,000 were contained in a specimen one-seventh of an inch square. Chrysoberyl, when large and transparent, is used as a gem, the opalescent varieties, named cymophane (floating light), being most valued.

165. Topaz, *Phillips, Werner, Hauy;* Prismatic Topaz, *Mohs, Jameson.*

Rhombic; ∞P (*M*) 124° 19′, 2P̆∞ (*n*) 93°, ∞P̆2 (*l*) 93° 8′, and numerous other forms, among which P (*o*) generally occurs. The character of the crystals is always prismatic (fig. 150), from the prevalence of the above prisms, which are bounded at the extremities by various forms, especially OP, P, ½P̆2 (*z*), or 2P̆∞. The crystals are often hemimorphic, being attached by one end singly or in druses. The prisms are finely striated. Also found massive, with indistinct crystalline structure, and disseminated in rounded fragments. Cleavage, basal very perfect, traces in several other directions, especially along *M* and *l* in the Scottish varieties. Fracture conchoidal or uneven. H. = 8; G. = 3·4 — 3·6. Transparent to translucent on the edges. Lustre vitreous. Colourless, but coloured yellowish, reddish, or greenish-white, honey-yellow, hyacinth-red, violet-blue, and mountain or asparagus-green. Becomes electric from heat or friction. Strongly heated in the closed tube with salt of phosphorus, or in the open tube when fused with carbonate of soda, shows reaction for fluorine. B.B. infusible alone, but in a strong heat small blisters form on the surface. With borax melts slowly to a clear glass; with cobalt solution the powder becomes blue. Not affected by hydrochloric acid, but by long digestion in sulphuric acid, gives traces of fluorine. Chem. com., according to Rammelsberg, a combination of silico-fluoride of aluminium (*Kiesel-fluoraluminium*) with silicate of alumina, or 12 $\ddot{A}i\,\dot{s}i$ + (2 $Al\,F^3$ + 3 $Si\,F^2$), which gives in 100 parts 35·26 silica, 54·93 alumina, and 17·14 fluorine (= 107·33); the overplus arising from the silicium and aluminium being considered as the earths. The latter member may be regarded as equivalent to $\ddot{A}i^2\,\dot{s}i^3$, with the oxygen replaced by fluorine. Analyses, next page.

Fig. 150.



Canton placed the chief electric poles of the topaz in the extremities of the prism. Hankel found four weaker poles, two in the obtuse, and two in the acute side edges; and Erman remarked that the electric axis did not coincide with that of the prism. P. Riess and G. Rose state that the two antilogue poles are situated in the obtuse side edges of the prism (∞P); whilst the two analogue poles unite in the middle of the diagonal joining these edges, or correspond to the macrodiagonal chief section. Many topazes contain small ca-

	Silica.	Alumina.	Fluoric acid.		Total.		
			A	B	A	B	
1	34·24	57·45	7·75	14·99	99·44	106·68	Berzelius, Saxony.
2	34·01	58·38	7·79	15·06	100·18	107·45	Do. Brazil (yellow).
3	34·36	57·74	7·77	15·02	99·87	107·12	Do. Finbo (Pyrophysalite).
4	...	54·88	17·33	16·50	...	...	Forchhammer, Brazil.
5	35·39	55·96	17·35	16·86	108·70	108·21	Do. Trumbull, Connecticut.
6	35·66	55·16	17·79	17·84	108·61	108·66	Do. Finbo (Pyrophysalite).

In Nos. 1-3, A is the fluoric acid given by Berzelius; B as corrected from the new atomic numbers by Rammelsberg. In Nos. 4-6, A and B are fluorine, the latter estimated from the loss, when the topaz was heated to the temperature at which cast iron melts.

vities filled with the peculiar fluids described by Sir D. Brewster. In others from Brazil he found a white, earthy substance, composed, according to Berzelius, of silica, alumina, lime, and water, and intumescing like zeolite before the blowpipe.

Topaz occurs chiefly in granite, but also in gneiss, mica-slate, and clay-slate. It is generally crystallized in druses, often accompanied by rock-crystal, and not uncommonly the one enclosed in the other, as in a specimen of Siberian topaz in the Museum of Mines at St Petersburgh, which contains a crystal of smoke-coloured rock-crystal, and weighs about thirty-two pounds. It is also frequently associated with tourmaline, beryl, and euclase, or with fluor-spar, lepidolite, and other minerals containing fluorine. The topaz-rock of Schneckenstein near Auerbach in Saxony, is a granular slaty mixture of quartz, schorl, and topaz, containing druses with crystals of quartz and topaz, with lithomarge. It is also found in several of the tin mines of Bohemia, Saxony, and Cornwall (St Michael's Mount), with crystals of quartz, lepidolite, tin, and fluor spar.

The topazes of commerce come chiefly from Brazil and Siberia. In the former they are found in Minas Novas and Minas Geraes, near Villa Ricca in nests of quartz with euclase and lithomarge, also near Rio Janeiro in loose sand with diamonds. The principal Siberian localities are Alabaschka near Mursinsk, the Ilmen Mountains, and the mountains near Nertschinsk. Kamtschatka, Asia Minor, Ceylon, New Holland, Peru, Trumbull and Middleton in Connecticut, are other localities. Small crystals have been found in the Mourne Mountains in Ireland. Some of the finest crystals are from the Cairngorum Mountains in Aberdeenshire, where one was found weighing nineteen ounces. Some from this locality are sky-blue, except on the acute edges of the prism, which are pale-brown.

The common or coarse columnar topaz is named Pyrophysalite; and is found in granite veins in gneiss at Finbo, and in loose blocks

at Broddbo near Fahlun. One crystal from the latter place in the College of Mines at Stockholm weighs eighty pounds.

Topaz is highly valued as an ornamental stone. The Brazilian are distinguished for deep yellow tints, but are changed by exposure to heat to pale-pink or red, like the Balas ruby, from which they are easily known by their electricity. In the Saxon topazes, pale wine-yellow prevails, but they become limpid from heat. The Mursinsk topaz has a peculiar bluish tinge. With these peculiarities of colour, others in crystalline form are associated. The purest from Brazil, named *Goutte d'eau*, when cut in facets like the diamond, closely resemble it in lustre and brilliance. The topazion of the ancients seems to have been a different mineral.

166. PYCNITE, *Hauy*; Stangenstein; Schorlite.

Massive, with a parallel columnar structure, and oblique transverse divisions, or cleavage. H. = 7·5; G. = 3·49 — 3·54. Translucent; lustre vitreous; colours straw-yellow to yellowish and reddish-white. Chem. com. $2\,\ddot{A}i^5\,\ddot{S}i^6 + (2\,Al\,F^3 + 3Si\,F^2)$ or topaz with two atoms less of alumina. Analyses.

	Silica.	Alumina.	Fluorine	Total.	
1	38·43	51·00	17·095*a*	106·525	Berzelius, Altenberg Saxony.
2	39·04	51·25	18·48	108·77	Forchhammer, Do.

(*a*) Fluoric acid, Rammelsberg (8·84, Berzelius).

In most physical characters this mineral agrees with topaz, of which it is usually considered a variety. But the above analyses show that it differs in composition; and Forchhammer thinks its structure indicates a monoclinohedric crystallization. Hausmann, however, affirms that the oblique divisions are not true cleavage planes, that the angles of the prism do not differ from those in topaz, and that like this mineral it has a perfect cleavage perpendicular to the axis of the prism. It occurs in the tin mines at Altenberg in Saxony, and at Schlackenwald, and Zinnwald in Bohemia, with quartz and lepidolite.

167. LEUCOPHANE, *Esmark*.

Triclinohedric (?); but crystals rare. They are tabular, and seem formed by 0P, ∞'P', $\infty\breve{P}\infty$, and $\infty\breve{P}\infty$. Mostly massive and columnar. Cleavage in three directions, of which two intersect at 53° 25, (in two directions intersecting at 80°, *Weibye*). Very difficultly frangible. H. = 3·5 — 4; G. = 2·974. In thin splinters, translucent or transparent, and almost colourless, in thicker pieces wine-

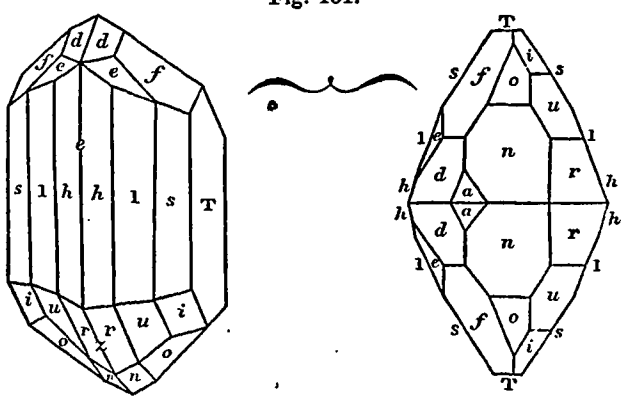
yellow or olive-green; lustre vitreous or resinous. B.B. fuses to a pale violet-blue bead; with borax to an amythest-coloured bead from manganese. In the open tube with salt of phosphorus gives reaction for fluorine. Chem. com. 3 $\dot{C}a\ \ddot{S}i + \dot{C}a^3\ \ddot{S}i^2 + Na\ F$. Analysis by Erdmann, 47·82 silica, 25·00 lime, 11·51 glucina, 1·01 manganese protoxide, 7·59 sodium, 0·26 potassium, 6·17 fluorine (= 99·36).

Found imbedded in syenite on the Lamöskjær near Brevig in Norway.

168. Euclase, *Hauy, Phillips;* Euklas, *Werner;* Prismatic emerald, *Jameson, Mohs.*

Monoclinohedric; C = 71° 7′, ∞P 114° 50′, P 105° 59′, P∞ 49° 17′; the combinations are frequently very complex, with many prisms and hemipyramids, but generally consist essentially of ∞P (*S*) . (∞P∞) (*T*) . P (*f*) (fig. 151). Cleavage, clinodiagonal highly

Fig. 151.



perfect; hemidomatic along P∞ less so; orthodiagonal in traces. Very brittle and fragile. Fracture conchoidal. H. = 7·5; G. = 3 — 3·1. Transparent; lustre splendent vitreous. Colour pale mountain-green, passing into yellow, blue, or white. B.B. in a strong heat intumesces, becomes white, and melts in thin splinters to a white enamel. With borax forms a colourless glass. Not affected by acids. Chem. com. $\dot{A}i^4\ \ddot{S}i^3 + 6\ \dot{G}^2\ \ddot{S}i$, with 43·9 silica, 32·2 alumina, and 23·9 glucina. Analysis of a specimen from Brazil, by Berzelius:—43·22 silica, 30·56 alumina, 21·78 glucina, 2·22 iron peroxide, 0·70 tin oxide (= 98·48).

Euclase, named from its extreme frangibility, is a rare mineral.

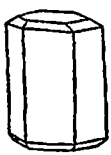
It was first brought from Peru, where it is said to occur in loose crystals, but has since been found in Brazil, at Boa Vista, and Capao do Lane, according to Eschwege, in druses of chlorite slate, with rock crystal, topaz, and lithomarge. More recently with the topaz at Trumbull, Connecticut; and also, it is said, at Lake Baikal in Siberia.

Euclase will take a fine polish, but its extreme fragility prevents its employment as an ornamental stone.

169. EMERALD, BERYL, *Phillips, &c.*; Emeraude, *Hauy*; Schmaragd, Beryl, *Werner, &c.*; Dirhombohedral Emerald, *Mohs.*

Hexagonal; P 59° 53′. The more usual forms are ∞P, 0P, ∞P2, P, and 2P2, and the most common combinations ∞P . 0P, and ∞P . ∞P2 . 0P (fig. 152). The crystals appear prismatic, and generally with vertical striæ. It is more rare in columnar aggregates. Cleavage, basal rather perfect; prismatic along ∞P imperfect. H. = 7·5 — 8; G. = 2·6 — 2·8. Transparent or translucent. Lustre vitreous. Colourless or white, but generally coloured, of various green shades, sometimes very brilliant, also yellow, and smalt-blue. B.B. melts with difficulty on the edges to an obscure vesicular glass; with borax forms a clear glass; slowly soluble in salt of phosphorus without leaving silica; and with fluor-spar forms a bead, colourless when hot, opaque and pale-green when cold. Not affected by acids. Chem. com. $\ddot{A}i\,\dot{S}i^3 + 3\,\dot{G}\,\dot{S}i$, or 67·5 silica, 18·7 alumina, and 13·8 glucina. Analyses.

Fig. 152.



	Silica.	Alumina.	Glucina.	Lime.	Chrome oxide.	Iron perox.	Tantalic acid.	Total.	
1	64·40	14·00	13·00	2·56	3·50	...	...	97·56	Vauquelin, Peru.
2	68·50	15·75	12·50	0·25	0·30	1·00	...	98·30	Klaproth, Do.
3	66·45	16·75	15·50	...	...	0·60	...	99·30	Do. Siberia.
4	68·35	17·60	13·13	...	...	0·72	0·72	100·52	Berzelius, Broddbo.
5	67·00	19·64	12·56	0·18	...	0·53	...	99·91	Scheerer, Fossum.
6	66·86	18·41	12·54	...	...	2·00	...	99·81	Thomson, Siberia.
7	69·70	16·83	13·39	...	...	0·24	...	100·16	C. Gmelin, Broddbo.
8	67·54	17·63	13·61	...	...	...	...	98·68	Do. Limoges.
9	67·36	16·46	12·75	...	...	1·50	0·28	98·35	Moberg, Somero, Finnland
10	66·62	16·51	12·75	...	...	3·03	0·10	99·01	Do. Tamela, Do.
11	69·51	14·49	15·41*a*	1·64*b*	...	...	...	101·05	Schlieper, S. America.

(*a*) With alumina; (*b*) with magnesia.

The rich deep-green varieties, coloured by chrome, Nos. 1, 2, are named emerald; the less brilliant or colourless, beryl. The Smaragdus of the ancients probably included malachite and the plasma or green quartz. They are said to have procured this stone from the Zabarah mines in Upper Egypt, but these, when recently reopened,

yielded no emeralds of any value. The Beryllus of Pliny seems more certainly the modern stone of that name. It was in this mineral that Vauquelin in 1797 discovered glucina.

Emerald occurs either imbedded or in druses in the crystalline rocks, especially granite, gneiss, mica, and talc slates. The noble emerald was first found in Peru in the Tunka valley near New Carthage, in veins in clay slate, hornblende slate, and granite, along with calc-spar, quartz, and pyrites. Less beautiful varieties have been since procured from mica-slate in the Heubach valley in Salzburg, and at Cangarjum in India, and more recently large crystals, but seldom wholly pure, along with phenakite and chrysoberyl on the Takowaya, east of Katharinenburg in Siberia. Allan mentions a crystal from Peru in the collection of the Duke of Devonshire above two inches long, weighing 8 oz. 18 dwts., and valued at 150 guineas, though containing numerous flaws; a perfect hexagonal prism in his father's collection measured an inch in each direction; and a cut crystal weighing six ounces in the possession of Mr Hope of London, which cost L.500, and was supposed to be the finest in Britain.

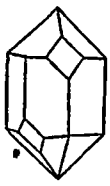
The finest Beryls or Aquamarine are found near Mursinsk, and Slatoust, in the Ilmen Mountains, and near Nertschinsk in Siberia, chiefly in druses or veins in granite along with rock crystal or tourmaline and topaz. Some crystals exceed a foot in length. Large crystals also occur in the United States, and one from Ackworth in New Hampshire, measured four feet long, five and a half inches across the faces, and weighed 238 lbs. Others smaller are found at Royalston in Massachusetts, Haddam in Connecticut, and many other localities. Fine crystals occur in granite in the Mourne Mountains in Ireland, and, though rarely, in the Cairngorum Mountains in Aberdeenshire. Salzburg and Brazil also yield the precious beryl; whilst Fahlun in Sweden, Fossum in Norway, Limoges in France, the Rabenstein near Zwiesel in Bavaria, the Schlakenwald tin mines in Bohemia, and many other places, are known localities of the common variety.

Emerald and Beryl are much valued as precious stones. Green glass is often substituted for it, as in the famous Reichenau emerald, and the so-called Holy Cup of Genoa.

170. PHENAKITE, *Nordenskiöld;* Rhombohedral emerald, *Mohs.*

Rhombohedric; R 116° 40′ (115° 25′ *Nord.*), usual combinations R . ∞P2, or ∞P2 . ⅔P2 . R (fig. 153), but frequently with other subordinate forms. Macles with parallel axes and perfectly intersecting, are also common. The crystals appear rhombohedric, or

Fig. 153.



short prismatic and pyramidal. Cleavage rhombohedric along R, and prismatic along ∞P2, not very distinct. Fracture conchoidal; H. = 7·5 — 8; G. = 2·97 — 3. Transparent or translucent; lustre vitreous. Colourless, and white, but coloured wine-yellow or brown. B.B. infusible alone; with borax forms a clear glass; with cobalt solution becomes dirty bluish-brown. Not affected by acids. Chem. com. $\dot{G}^2\ddot{S}i$, with 55 silica, and 45 glucina. Analyses.

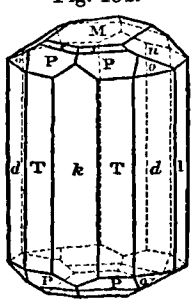
	Silica.	Glucina.	Magnesia.	Total.	
1	55·14	44·47	traces*a*	99·61	Hartwall, Ural.
2	54·40	45·57	0·10*b*	100·07	Bischof, Framont.

(*a*) With alumina; (*b*) with lime.

First found in the mica-slate on the Takowaja, 85 versts east of Katharinenburg, in crystals one or two inches long but generally of simple forms, along with emerald and chrysoberyl. Since near Framont in Alsace in brown iron ore with quartz, and more recently in the Ilmen Mountains, east of Miask, with topaz and green felspar in granite veins in miascite. The crystals from Framont are small, but with many faces, and remarkable for their peculiar hemihedric, hemimorphic, and macled forms. The Ilmen crystals are also small, with many faces, but regular forms and no trace of macles or hemimorphism. When polished, phenakite forms a very splendent ornamental stone.

171. IOLITE, *Werner, Jameson, Phillips;* Cordierite, *Hauy;* Dichroite, *Cordier, Hausmann;* Prismatic quartz, *Mohs.* Rhombic; ∞P 119° 10′ (*Breithaupt*), middle edges of P about 125°.

Fig. 154.



Some of the more common combinations are ∞P (*T*) . ∞$\breve{P}$∞ (*l*) . . 0P(*M*), and this with ∞$\bar{P}$∞ (*k*), ∞$\breve{P}$3 (*d*), $\breve{P}$∞ (*n*), and $\frac{1}{2}$P (*s*), or other forms (fig. 154). The crystals, often indistinctly formed, are short, prismatic, resembling hexagonal or twelve-sided prisms, and frequently exhibit a foliated structure along 0P. Cleavage, brachydiagonal rather distinct, traces along $\bar{P}$∞. Fracture conchoidal or uneven. H. = 7—7.5; G. = 2·5—2·7. Transparent or translucent; lustre vitreous, inclining to resinous; colourless, but coloured in many shades of blue, green, brown, yellow, and

grey. Many varieties show a distinct pleochroism. B.B. fuses slowly to a clear glass; slowly soluble in borax and salt of phosphorus; with cobalt solution forms a blue or bluish-grey glass. Slightly affected by acids. Chem. com. $\ddot{A}i^2\,\ddot{s}i^3 + 2\,\dot{M}g\,\ddot{s}i = 52$ silica, 34·5 alumina, and 13·5 magnesia, but the latter partly replaced by protoxide of iron or manganese. Analyses.

	Silica.	Alumina.	Magnesia.	Iron protx.	Mang. protx.	Loss by heat.	Total.	
1	48·35	31·71	10·16	8·32	0·33	0·60	99·46	Stromeyer, Bodenmais, Bavaria.
2	49·17	33·11	11·45	4·34	0·04	1·20	99·31	Do. Simiutak, Greenland.
3	48·54	31·37	11·31	5·69	0·70	1·69	99·65	Do. Orrijerfvi, Finnland.
4	50·25	32·42	10·85	4·00	0·69*a*	1·66	99 87	Do. Fahlun.
5	48·53	31·50	15·00	1·61	0·24	1·71	98·59	Thomson, Orrijerfvi.
6	49·62	28·72	8·64	11·58	1·51	... *b*	100·30	Do Connecticut.
7	48·6	30·5	8·2	10·7	0·1	1 5 *c*	100·8	Schütz, Finspang, E. Gothland.
8	48·35	32·50	10·00	6·00	1·10	3·10	100·05	Jackson, Haddam, Connecticut.
9	48·15	32·50	10·14	7 92	0·28	0·50	99·49	Do. Unity, N. Hampshire.
10	50·44	32·95	12·76	1·07*a*	...	1·02*d*	99·36	Scheerer, Krageroe, Norway.

(*a*) Peroxide; (*b*) + 0·23 lime; (*c*) + 0·2 undecomposed; (*d*) + 1·12 lime.

This mineral was first described by Cordier, who thought its crystallization hexagonal, and named it *dichroite* from the change of colours. It however presents three tints, or dark-blue along the chief axis, lighter blue in an oblique direction, and colourless, or greyish or brownish-yellow, at right angles. Haidinger distinguishes even six tints in different positions. Plates cut either parallel or at right angles to the axis polarize light like tourmaline. It was first found in granite at Cabo de Gata in Spain with quartz and garnet. Afterwards in fine imbedded crystals or massive (*Peliom*) at Bodenmais in Bavaria with magnetic pyrites, copper pyrites, zinc blende, and mica; and at Orrijerfvi (the *Steinheilite*) with copper pyrites. Also in quarz and gneiss near Tvedestrand and Brevig in Norway, and in several places in Sweden, whence it has been transported with the granite boulders to Northern Germany. *Hard fahlunite* is a reddish-brown massive variety (No. 4) from Fahlun. It also occurs in Greenland, North America, and Siberia. Small rolled masses of an intense blue colour and transparent, found in Ceylon, are the *sapphire d'eau* or *Luchssapphir* of the jewellers, but are not highly valued. It is also said to occur in the trachyte of Lake Laach on the Rhine.

The following minerals have been often considered distinct species, but seem to want the definite crystalline and chemical characters that would entitle them to this rank. Haidinger, Dana, and others consider them with more probability as mere pseudomorphs of iolite. They are essentially silicates of alumina, and another base, often iron

protoxide, but mixed with many other substances. In some the water seems incidental, absorbed during decomposition, when the iron also passes into the peroxide.

(*a*) *Bonsdorffite* (Thomson, Min. p. 323), *Hydrous Iolite* (Ib. p. 278), greenish-brown, or dark olive-green; found near Åbo with iolite, from which it only differs in containing 4 atoms of water. No. 1 is only an approximation, the exact numbers having been lost in a fire at Åbo.

(*b*) *Esmarkite* of Erdmann, *Chlorophyllite* of Jackson, occur in large 4, 6, 8, or 12 sided prisms, or in foliated masses of a green or brownish colour, contain less water, or only 2 atoms. The former is found at Bräkke near Brevig in Norway (anal. No. 2); the latter at Unity in Maine (No. 3); and Haddam in Connecticut, where it sometimes contains the unaltered iolite in the interior. It shows mere traces of phosphoric acid.

(*c*) *Fahlunite* of Hisinger, *Triclasite* of Hauy; compact, green or brown, with a conchoidal or uneven fracture. H. = 2·5 — 3; G. = 2·5 — 2·8. It occurs in the talc and chlorite slates at Fahlun, and a foliated variety with a threefold cleavage in the deepest part (190 fathoms) of the copper mines. Analyses Nos. 4, 5 (compact, brownish-green), 6 (black, foliated), 7 (crystallized).

(*d*) *Weissite*, externally like fahlunite, but said to be monoclinohedric; occurs in kidney-shaped masses with indistinct cleavage, and ash-grey or brown colours, at Fahlun (No. 8), and in Lower Canada (No. 9).

(*e*) *Pinite* of Werner and Hauy, *Gieseckite* of Sowerby; crystallized

	Silica.	Alumina.	Magnesia.	Iron prot.	Mang. prot.	Lime.	Soda.	Pot-ash.	Watr.	Total.	
1	45	30	9	5	...	...	...	...	11	100	Bonsdorff.
2	45·97	32·08	10·32	3·83	0·41	0·45*a*	...	...	5·49	98·55	Erdmann.
3	45·20	27·60	9·60	8·24	4·08	...	...	...	3·60	98·32	Jackson.
4	46·79	26·73	2·97	5·01	0·43*b*	...	...	...	13·50	95·43	Hisinger.
5	43·51	25·81	6·53	6·35*b*	1·72	trace	4·45	0·94	11·66*c*	101·13	Trolle-Wachtmeis-
6	44·60	30·10	6·75	3·86	2·24	1·35	trace	1·98	9·35*d*	100·23	Do. [ter.
7	44·95	30·70	6·04	7·22	1·90	0·95	...	1·38	8·65*d*	101·79	Do.
8	59·69	21·70	8·99	1·43	0·63	...	0·68	4·10	3·20 *e*	100·72	Do.
9	55·05	22·60	5·70	12·60	trace	1·40	...	...	2·25	99·60	Tennant.
10	55·96	25·48	3·76	5·51*b*	...	...	0·39	7·89	1·41 *e*	100·40	C. Gmelin.
11	54·6	23·6	0·8	7·8	1·6*b*	...	...	11·2	1·2	100·8	Ficinus.
12	48·00	29·00	...	9·66*b*	...	0·75	...	11·35	3·00	100·76	Scott.
13	46·08	33·83	1·20	3·36	1·16*b*	...	...	6·20	4·89	96·71	Stromeyer.
14	48·0	32·5	1·5	4·0*b*	...	...	...	6·5	5·5	98·00	Pfaff.
15	46·27	25·10	3·30	15·60*b*	0·89	...	1·20	2·70	6·00*f*	101·56	Trolle-Wachtmeis-
16	45·5	26·7	2·4	12·4	0·9	...	...	5·8	6·2	100·9	Komonen. [ter.
17	40·94	28·79	13·73	6·96	0·32	0·50*g*	...	...	7·38	98·62	Erdmann.
18	36·16	27·50	12·50	9·28	0·68	traces *g*	...	...	8·11	96·33	Do.

(*a*) With lead, copper, cobalt, and titanium; (*b*) peroxide; (*c*) + 0·16 fluoric acid; (*d*) + trace of fluoric acid; (*e*) with traces of ammonia, and 0·30 zinc oxide; (*f*) trace of ammonia and fluorine; (*g*) oxides of lead, copper, and cobalt, with lime and titanic acid.

like iolite, or massive and laminar, with imperfect cleavage. H. = 2 — 3; G. = 2·7 — 2·9. Semitranslucent or opaque; dull or resinous; and dirty-grey, green, or brown. It yields water in the closed tube; and B.B. fuses to a glass, sometimes clear, at other times dark-coloured. Chem. com. like iolite, with potash and water (Nos. 10–14). The Pinite occurs chiefly in granite or felspar-porphyry, and more rarely in gneiss and mica-slate; as in Auvergne (No. 10); in the Pini mine near Schneeberg at Neustadt near Stolpen (No. 11); at Penig in Saxony (No. 12); in the Harz, Cornwall, Aberdeenshire, and several parts of the United States. The Gieseckite (Nos. 13, 14) is brought from Greenland. Pinite is frequently mixed with scales of mica, and the Gieseckite with felspar; and Shepard observed the Pinite of Haddam, Connecticut, so conjoined with iolite as to leave no doubt of their identity. The *Oosite* from Geroldsau in Baden, snow-white, opaque, fragile, in six or twelve-sided prisms, and easily fusible, also resembles pinite, but has not been fully examined.

(*f*) *Gigantolite* of Nordenskiöld, occurs in large twelve-sided prisms, probably rhombic, with angles of 148° and 152°, bounded by planes rather of division than cleavage, as they are often covered by laminæ of chlorite. H. = 3·5; G. = 2·8 — 2·9. It is opaque, dull resinous, and greenish-grey or brown. B.B. intumesces slightly, and fuses easily to a greenish slag; with borax forms a clear glass, slightly tinged by iron, Anal. Nos. 15, 16. Occurs in nests in granite near Tammela in Finnland, and decomposes readily on exposure.

(*g*) *Praseolite* of Erdmann; occurs in rounded prisms, probably rhombic of four, six, eight, or twelve sides, with a basal cleavage or lamellar structure, and flat conchoidal or splintery fracture; H. = 3·5; G. = 2·754. It is opaque or semitranslucent, dull resinous, and green. B.B. fuses with difficulty on the edges to a bluish-green glass. No. 17 is a crystallized, No. 18 a compact variety. It occurs in quartz veins in gneiss at Brakke, near Brevig in Norway. Haidinger mentions a specimen in the Vienna collection, the interior of which is still unaltered iolite.

172. TOURMALINE, *Phillips*, *Hauy*; Turmalin, Schörl, *Werner*; Rhombohedral Tourmaline, *Mohs*.

Rhombohedric; R 133° 10′ (from 132° to 134°, *Breithaupt*), the most usual forms are 0R (*k*), — ½R (155°) (*n*), R (*P*), — 2R (103° 3′) (*o*), ∞P2 (*S*), and ∞R (*l*), but with many subordinate faces. Remarkable for hemimorphism, ∞R appearing as a trigonal prism. The general aspect of the crystals is long prismatic, rarely short prismatic, and still more rarely rhombohedric. They are especially formed

by ∞P2 and ½ ∞R, and bounded by rhombohedrons (figs. 155, 156).

Fig. 155.

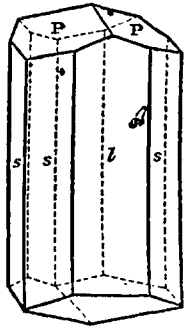
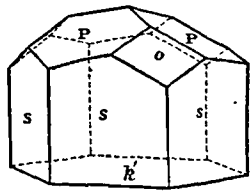


Fig. 156.



The prisms are generally striated vertically, and the crystals occur imbedded or attached. Also found massive in radiating, confused columnar, or fibrous aggregates. Cleavage, rhombohedric, along R, and prismatic along ∞P2, both imperfect. Fracture conchoidal or uneven; H. = 6·5 — 7·5; G. = 3 — 3·3. The black varieties opaque, the others pellucid in all degrees. Lustre vitreous. Colourless, but usually coloured grey, yellow, green, blue, red, brown, and most frequently black. Often several colours in layers perpendicular to the axis, or parallel to it, and enclosing each other. By friction acquires positive, by heat polar electricity. Powder white, often magnetic. B.B. act very variously,—of the potash tourmalines, the black fuse with much intumescence, become white, and form a greyish-yellow bead; the Bovey variety forms a black slag; the green from Brazil a yellowish slag,—of lithia (and soda) tourmalines, the red and light-green swell, but without fusing, and with soda show reaction for manganese; the light-blue act almost the same; the dark-blue (indicolite) intumesce very much, and then become black and slaggy. With fluor-spar and sulphate of potash all show reaction for boracic acid. In powder not soluble in hydrochloric, only imperfectly in sulphuric acid; after fusion almost wholly soluble by long digestion in concentrated sulphuric acid. Analyses, next page.

These analyses show the exceedingly complex and variable composition of this mineral. No general formula has yet been given, thus confirming Breithaupt's view, that tourmaline really consists of several species. Naumann states that generally tourmaline is a double salt of silica, in which 12 atoms silica combine with 8 atoms R (alumina and peroxide of iron or manganese), and with 2, 3, 4, or

	Silica.	Boracic acid.	Alumina.	Iron protoperox.	Iron prot.	Mang. perox.	Magnesia.	Lithia	Lime.	Soda.	Potash	Volatile.	Total.
1	42·13	5·74	36·43	...	...	6·32	...	2·04	1·20	...	2·41	1·31	97·58
2	39·37	4·18	44·00	...	...	5·02	...	2·52	...	...	1·29	1·58	97·96
3	39·16	4·59	40·00	5·96	...	2·14	...	3·59*d*	...	...	...	1·58	97·02
4	38·80	3·88	39·61	7·43	...	2·88*e*	...	...	...	4·95	...	0·78	98·33
5	38·79	3·63	37·19	5·81	...	trace	5·86	...	...	3·13	0·22	1·86	96·48
6	35·20	4·11	35·50	17·86	...	0·43	0·70*f*	...	0·55	2·09	...	...	96·44
7	33·05	1·89	38·23	...	23·86	...	...	...	0·86	3·17*e*	...	0·45	101·51
8	35·48	4·02	34·75	17·44	...	1·89	4·68	...	trace	1·75	0·48	...	100·49
9	37·65	3·83	33·46	9·38	...	...	10·98	...	0·25	2·33*d*	...	0·03	98·11
10	37·81	4·18	31·61	7·77	...	1·11	5·99	...	0·98	...	1·20	0·24	90·89
11	40·30	1·10	40·50	4·85*b*	..	1·50	..	4·30	...	...	...	3·60	96·15
12	41	9	32	5 *b*	...	1	3	5	...	...	...	...	96
13	38·25	2·64	32·64	21·45	...	0·45	1·50	..	...	2·70	...	...	99·63
14	44·10	5·72	26·36	...	11·96	...	6·96	..	0·50	...	2·32	0·60*g*	98·46
15	39·00	10·73	30·65	1·58*b*	6·10	...	9·44	...	...	...	...	2·50*h*	100·00
16	37·80	9·90	30·56	0·50*b*	12·07	2·50*a*	1·42	0·50	...	2·09	...	1·66*h*	100·00
17	40·54	11·79	31·77	...	3·65	0·90*a*	6·44	2·09	...	...	1·17*i*	1·66*h*	100·00
18	42·88	5·34	44·09	...	...	0·27	0·45	2·19	...	3·12	...	1·66*h*	100·00
19	39·70	6·65	40·29	...	...	2·30	0·16	3.02	...	7·88	..	...	100·00

(*a*) Protoxide; (*b*) peroxide; (*d*) with potash; (*e*) with potash and traces of magnesia; (*f*) with manganese protoxide; (*g*) water; (*h*) carbonic acid; (*i*) chrome.

These analyses are by (Nos. 1–10) C. Gmelin; (11) Arfvedson; (12) Grüner; (13) Dumenil; (14) Le Play; (15–19) Hermann.

The specimens were from—(1) Rozena, Moravia, red T.; (2) Perm, Siberia, red; (3) Brazil, green, T.; (4) Chesterfield, N. A., green; (5) Greenland, black; (6) Bovey, Devonshire, black; (7) Eibenstock, Saxony, black; (8) Rabenstein, Bavaria, black; (9) Käringbricka, Westmanland, black; (10) St Gotthardt, dark-brown; (11) Utoen, blue; (12) Greenland, green; (13) Sonnenberg, Harz, black; (14) Monte Rosa, black; (15) Gornoschit near Katharinenburg, black; (16) Mursinsk, brown; (17) Totschilnaja Gora, Ural, green; (18) St Pietro Elba, colourless; (19) Sarapulsk near Mursinsk, rose-red.

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6 atoms $\dot{R}$ (magnesia, protoxides of iron and manganese, soda, lithia, and potash), to which about 1 atom boracic acid must be added.

Rammelsberg formerly arranged the turmalines in three groups, as Lithia (Nos. 1, 2, 3, 11, 12); Soda (Nos. 4, 6, 7, 13); and Magnesia (Nos. 5, 8, 9, 10, 14), tourmalines; but since gives the views of Hermann. This chemist divides the varieties he examined into three species, or Schorl (Nos. 15, 16, 17), Achroite (No. 18), and Rubellite (No. 19), and states that the schorl alone polarizes light, and comprises the iron turmalines intumescing B.B.; that the achroite includes the colourless varieties; and the rubellite the red, with a considerable proportion of manganese. For these he gives the formulæ:—

(*a*) Schorl = $\dot{R}$ ($\ddot{B}$, $\ddot{C}$) + $\ddot{Al}$ $\ddot{Si}$, or $\dot{R}^3$ $\ddot{B}^2$ + $\ddot{Al}^3$ $\ddot{Si}$,
with $\dot{R}$ = Fe, Mg, Li Na.

(*b*) Achroite = 2 $\dot{R}$ ($\ddot{B}$, $\ddot{C}$) + 3 $\ddot{Al}^2$ $\ddot{Si}^3$, or $\dot{R}^3$ $\ddot{B}^2$ + 9 $\ddot{Al}$ $\ddot{Si}$,
with $\dot{R}$ = Na, Li, Mg, Mn.

(*c*) Rubellite = 2 $\dot{R}^2$ $\ddot{B}$ + 3 $\ddot{Al}^2$ $\ddot{Si}^3$, or 2 $\dot{R}$ $\ddot{B}$ + 9 $\ddot{Al}$ $\ddot{Si}$,
with $\dot{R}$ = Na, Li, Mn, Mg.

Hermann adopts the view that the acids contain two atoms oxygen,

and the second formulæ are the equivalents of the first given by Rammelsberg on the usual theory, and neglecting the carbonic acid, first observed by Hermann, but the amount of which is not yet well ascertained. As all these combinations have similar crystalline forms, Hermann names them Heteromerous. More numerous and precise analyses will be needed before this division can be definitely adopted.

Some varieties of tourmaline are remarkable for their dichroism. Wagner mentions a crystal, which, when looked through along the axis, was purple-red, and at right angles to it a beautiful sapphire-blue. Other crystals show distinct colours or degrees of transparency in different parts, from variations either in the amount or nature of the colouring matter. Thus, some from Siberia, and Chesterfield in Mass., have a kernel coloured red by manganese in the centre of a shell coloured green by iron. Some Siberian tourmalines, of a dark-green or brownish-black colour at the attached end, pass towards their free extremity into a fine ruby-red, increasing in purity till it becomes quite transparent. Others from Elba are dark-blue in the centre, and red at the extremities of the crystals. Its pyro-electric properties, observed in 1707 by Dr Garmann, and in 1717 by Lemery, have been frequently investigated since. According to G. Rose, the position of the electric poles may generally be known from the form of the crystal. In forms like fig. 155, the upper end where the face of the primary rhombohedron is placed against the edges of the faces of the trigonal prism $\frac{1}{2}\infty R$ (*l*) are antilogue poles, whilst the under end where the rhombohedron face is opposite the face of the prism are analogue. But the opposite distribution is seen, though more rarely, as in the beautiful crystals from Gouverneur in New York, those of Bovey-Tracey in Devonshire, and Sonnenberg near Andreasberg, to which Haidinger adds a yellowish-brown variety from Brazil. The pure, transparent crystals without flaws possess a higher electricity than the black, opaque, common varieties.

Tourmaline, though a wide-spread mineral, is not of high geological importance, as it only forms an essential constituent of schorl-rock and topaz-rock, both very limited masses. It has hitherto been found only in the older plutonic and metamorphic rocks, and never either in the newer stratified or in the recent trap and volcanic formations. It is very common in granite, where it sometimes replaces the mica. It is frequently associated with quartz, orthoclase, albite, mica, lepidolite, chlorite, topas, and beryl, either in druses or in subordinate beds; or with their crystals enclosed or intermixed in each other. Some tourmaline crystals from Pfitsch in Tyrol, and Kosoibrod in the Ural, pass into a similar shaped mass of scaly chlorite; in others mica assumes a similar position, as if forming pseudomorphs of tourmaline.

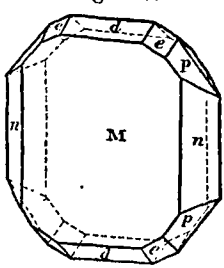
There is also occasionally a similarity in the chemical composition of the minerals thus associated, as the red lithia tourmaline with lepidolite, the soda tourmaline with albite.

The more important localities of this mineral may be found in the table above. The finest transparent varieties or noble tourmalines come from Ceylon, Siberia, and Brazil. A celebrated specimen of the red variety, the Rubellite or Siberite, presented to Mr Greville by the king of Ava, and now in the British Museum, was valued at L.500. The dark-blue or Indicollite occurs chiefly in Utoe. Large crystals of the dark opaque varieties named schorl occur in Greenland, Arendal, the Tyrol, and various parts of North America. In England, Bovey in Devonshire and St Just in Cornwall are well-known localities, and in Scotland large curved semi-crystalline prisms are found in the granite of Portsoy.

Tourmaline is not much valued as a gem, the colours being rarely pure. Sometimes it is employed to imitate more valuable stones, but may be easily known from its pyro-electric properties.

173. CHRYSOLITE, *Phillips;* Krisolith, Olivin, *Werner;* Peridot, *Hauy;* Prismatic chrysolite, *Jameson*, *Mohs.*

Fig. 157.



Rhombic, ∞P (*n*) 130° 2′, $\breve{P}\infty$ (*d*) 76° 54′ $\breve{P}\infty$ (*h*) 119° 12′, $2\breve{P}\infty$ (*h*) 80° 53′; besides these other forms, especially $\infty\bar{P}\infty$ (*M*), $\infty\breve{P}\infty$ (*T*), with P (*p*), 0P occur (fig. 157). The crystals are frequently prismatic from predominance of several prisms, and of the macropinakoids, chiefly limited by $2\breve{P}\infty$ and $\bar{P}\infty$. It occurs in imbedded crystals, or in loose fragments and grains; also massive and granular, or disseminated. Cleavage, brachydiagonal, along $\infty\breve{P}\infty$, rather distinct, macrodiagonal very imperfect; fracture conchoidal; H. = 6·5 — 7; G. = 3·3 — 3·5. Transparent or translucent; lustre vitreous; colour olive to asparagus and pistacio-green, also yellow and brown. B.B. infusible, except the variety (Hyalosiderite) containing much iron, which forms a black magnetic globule. Easily soluble and gelatinizing in sulphuric acid (also in hydrochloric acid, according to Berzelius). Chem. com. $\dot{R}^2$ Si, in which $\dot{R}$ is partly magnesia and partly protoxide of iron. Analyses, next page.

	Silica.	Magnesia.	Iron protx.	Manganprotx.	Nickel protx.	Alumina.	Total.	
1	39·73	50·13	9·49	0·09*a*	0·32	0·22	99·68	Stromeyer, Oriental Chrysolite.
2	40·09	50·49	8·17	0·20*a*	0·37	0·19	99·51	Do. Vogelsberg, Giessen, Basaltic O.
3	40·45	50·67	8·07	0·18*a*	0·33	0·19	99·89	Do. Kasalthoff, Bohemia, Ol.
4	41·54	50·04	8·66	0·25	...	0·06	100·55	Walmsted, Iserweise, Ol.
5	41·42	49·61	9·14	0·15	...	0·15	100·47	Do. Bohemia, Ol.
6	41·44	49·19	9·72	0·13	...*b*	0·16	100·85	Do. Le Puy, Vivarais.
7	40·12	44·55	15·32	0·29	...	0·14	100·42	Do. Monte Somma (m. of 2).
8	40·00	43·09	16·27	0·55*c*	...	0·06	99·91	Lappe, Greenland.
9	38·48	48·42	11·19	0·34	...	0·18	98·61	Stromeyer, Pallas' Meteorite.
10	40·83	47·74	11·53	0·29	...	traced	100·39	Walmstedt, Do.
11	40·86	47·35	11·72	0·43	...*c*	...	100·53	Berzelius, Do.
12	38·25	49·68	11·75	0·11	...*d*	...	99·79	Stromeyer, Met., Otumba, S. A.
13	61·81	25·83	9·12	9·31	...*f*	...*c*	97·92	Do. Met., Grimma?

(*a*) Peroxide; (*b*) + 0·21 lime; (*c*) with nickel protoxide, and traces of copper protoxide; (*d*) with lime; (*e*) + 0·17 tin oxide; (*f*) + 0·33 chrome oxide, and 0·45 loss by heat.

The fine green coloured, transparent, and crystallized varieties are named chrysolite; the less pellucid masses of inferior colour, olivine. The former come chiefly through Constantinople from some unknown locality, and also occasionally from Brazil. Olivine occurs chiefly in basalt, in which it is rarely wanting, and also in amygdaloid, dolerite, in some of the more compact lavas, and in the blocks ejected from Vesuvius. It is more rare in obsidian and hypersthene rock. It is seldom crystallized; but some crystals, several inches in diameter, have been procured from the compact greenstone at Unkel on the Rhine; large compact masses near Cassel, Krainfeld in Darmstadt, and other parts of Germany. It is most common in small rounded grains. It is well known in some of the trap rocks of Arthur Seat, and of many other parts of Scotland.

It also occurs in meteoric iron,—especially in the mass found by Pallas in Siberia, in those of Atacama and Otumpa in South America, and in that of Brachin in Russia,—either as olivine or chrysolite, and sometimes crystallized, more frequently in rounded grains, and often mixed with other mineral matter. Stromeyer affirmed that meteoric olivine contained no nickel, which he found in all terrestrial olivines; and Berzelius confirmed this, at least of that from the Pallas' meteorite, which, however, contained tin oxide, whilst in others he observed oxide of copper. Rumler has discovered arsenious acid in the olivine of the Pallas' and Atacama iron, which has not been found in the common mineral.

Chrysolite is used as an ornamental stone, but is not much valued, from its softness and frequent flaws and cavities.

Connected with olivine, or mere varieties, are the following minerals:—

Hyalosiderite of Walchner, brown or yellow coloured, very ferruginous and metallic-looking; H. = 5; G. = 2·875, in other respects

like olivine. It is found in the Kaiserstuhl in the Breisgau, at Limburg near Sasbach, and in dolerite veins in the gneiss of the Bromberg near Freiburg. Analysis No. 1. The *Chusite* and *Limbelite* of Saussure, with the *Tautolite* of Breithaupt, from a felspar rock near Lake Laach, seem subordinate varieties.

Batrachite of Breithaupt; greenish-grey or white; translucent with imperfect cleavage, and rarely crystallized; from the Rizoni Mountain, Tyrol. Analysis No. 2.

Monticellite of Brooke, from the ejected limestone blocks on Vesuvius; transparent; colourless or yellowish; powder soluble in acids. Brooke describes its angles as differing from those of chrysolite, with which, according to Sacchi, they agree.

Fayalite of C. Gmelin; crystalline, with a tendency to a columnar foliated texture, but often appearing as if fused. It is greenish or pitch-black, brownish or brass-yellow, with a resinous or metallic lustre. It is cleavable in two directions, forming a very obtuse angle. H. = 6·5; G. = 4·15. Partly soluble, partly not in hydrochloric acid. Occurs among fragments of trachyte on the shore of the island Fayal. Hausmann regards it as a compound of which the soluble portion belongs to the chrysolite formation. Analyses Nos. 3, 4 of the decomposible portion; 5, 6 indecomposible. These were in the proportion of 84·1 to 15·9, Gmelin; 87·26 to 12·74, Fellenberg.

Knebellite of Dobreiner; massive, opaque, grey, green, brown, or red, from an unknown locality, may be included. Analysis No. 7.

	Silica.	Magnesia.	Iron prot.	Mang. prot.	Alumina.	Lime.	Potash.	Copper protox.	Total.	
1	31·63	32·40	28·49	0·48	2·21	...*a*	2·79	...	98·00	Walchner.
2	37·69	21·79	2·99	...	...	35·45	...	...*b*	99·19	Rammelsberg.
3	24·93	...	65·84	2·94	1·84	...	2·77*c*	0·60	98·92	C. Gmelin.
4	31·04	...	62·57	0·79	3·26	0·43	1·71*d*	0·32	100·13	Fellenberg.
5	58·11	...	18·55	6·67	12·53	...	...	2·23	98·14	C. Gmelin.
6	16·28	18·66	49·87	...	9·51	2·75	0·52*d*	2·10	99·69	Fellenberg.
7	32·5	...	32·0	35·0	...	...	...	...	99·5	Dobreiner.

(*a*) + trace of chrome; (*b*) + 1·27 water; (*c*) sulphuret of iron; (*d*) oxide of lead.

With these minerals many of the slags from iron furnaces agree. They exhibit the most complete similarity to the Fayalite; but Mitscherlich and Hausmann have shown that they are also analogous to chrysolite, both in chemical composition and in crystallization. The latter is occasionally very perfect, with distinct cleavage; at other times only a tendency to crystallization appears in the formation of thin rectangular tables. The following analyses of these slags are interesting for comparison.

	Silica.	Magnesia.	Iron prot.	Mang. prot.	Alumina.	Lime.	Potash.	Copper, &c.	Total.	
							...	...	99·05	Mitscherlich.
1	31·16	0·65	67·24	...	...	...	0·20	...	99·16	Walchner.
2	32·96	1·90	61·24	1·30*a*	1·56	...	0·29	...	99·75	Do.
3	32·35	1·40	62·04	2·65*a*	1·02	...	...	...	100·00	Mitscherlich.
4	30·93	...	69·07	...	...	...	0·18	2·65	99·40	Walchner.
5	29·25	1·30	63·32	1·46*a*	1·24	...		0·46*b*	99·55	Forbes.
6	22·76	0·76	61·20	3·50	7·30	3·41	...	*c*	101·32	Percy.
7	29·60	0·35	48·43	1·13	1·28	0·47	...	... *d*	102·08	Do.
8	23·86	0·24	39·43	6·17	0·91	0·28	...	...		

(*a*) Peroxide; (*b*) sulphur; (*c*) + 17·11 iron peroxide, 1·34 phosphoric acid, 1·61 sulphuret of iron; (*d*) + 23·75 iron peroxide, 6·42 phosphoric acid, and 0·62 sulphuret of iron.

(No. 1) is a crystalline iron slag; (2) do. from Dax in the Pyrenees, G. = 3·700.; (3) do. from Badenhausen in the Harz, G. = 3·529; (4) crystalline copper slag; (5) do. from Lautenthal in the Harz; (6) "Refinery cinder" from Bromford Iron Works, Birmingham; (7) slag from Mr Dawes' Iron Works, Birmingham, crystallized like olivine; (8) slag from Blomfield Iron Works, Tipton.

174. CHONDRODITE, *d'Ohsson*; Condrodite, *Phillips*, *Haüy*; Maclurite, *Seybert*; Brucite, *Gibbs*; Hemiprismatic Chrysolite, *Mohs*.

Monoclinohedric, according to Dana; ∞P 63°, P 80°, —P 89°; rarely in distinct crystals, chiefly in round imbedded grains or granular aggregates. Cleavage indistinct; fracture imperfect conchoidal; H. = 6·5; G. = 3·15 — 3·25. Transparent or translucent. Lustre vitreous or resinous. Colour straw or orange-yellow, hyacinth-red, brown, green, and almost black. Streak white or yellowish. B.B. becomes opaque, milk-white or brownish, and fuses on very thin edges. With borax fuses slowly to a clear glass slightly tinged by iron. In open tube, with salt of phosphorus, shows traces of fluorine. Decomposed by acids. Chem. com. $3\,\dot{M}g^2\,\ddot{S}i + Mg\,F = 37{\cdot}28$ silica, 50·06 magnesia, 5·11 magnesium, 7·55 fluorine; or, in analysis, 58·40 magnesia. Analyses.

	Silica.	Magnesia.	Iron protox.	Potash.	Fluorine.	Watr.	Total.			
1	32·67	54·00	2·33 *a*	2·11	4·09*b*	1·00	96·19	Seybert, New Jersey.		
2	36·00	53·64	3·97 *a*	...	3·75*b*	1·62	98·98	Thomson, Eden, New York.		
3	33·06	55·46	3·65	...	7·60	...	99·77	Rammelsberg, N. America (yellow).		
4	33·97	56·97	3·48	...	7·44	...	101·68	Do.	Do.	Do.
5	33·10	56·61	2·35	..	8·69	...	100·75	Do.	Pargas,	Do.
6	33·19	54·50	6·75	...	9·69	..	104·13	Do.	Do.	(grey).

(*a*) Peroxide; (*b*) fluoric acid.

Chondrodite occurs in granular limestone at Pargas in Finnland, Åker, and Gullsjö in Sweden. In a similar position in several parts of North America, as near Sparta in Sussex county in New Jersey, and in Orange county in New York. It has also been found in a bed of magnetic iron ore in gneiss, imbedded in dolomite or bitterspar in the Taberg in Wermeland. Also in Saxony; and with magnetic and arsenical pyrites on Loch Ness in Scotland.

The *Humite* of Bournon, from the ejected masses of Monte Somma,

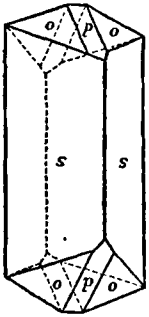
is considered as chondrodite by Monticelli and Covelli, a view confirmed by G. Rose, who finds fluorine in it, and considers its crystallization as monoclinohedric. It has a perfect cleavage in one direction; is transparent; vitreous; brown, yellow, or almost white; scratches glass; and B.B. infusible. Its composition is unknown; and the crystallization both of it and chondrodite need further investigation.

XII. Family.—Metallic Stones.

175. Lievrite, *Werner, Jameson;* Yenite, *Phillips;* Ilvaite, *Hausmann;* Diprismatic Melan-ore, *Mohs.*

Rhombic; P, polar edges 138° 26′ and 117° 34′, ∞P 111° 12′, $\breve{P}\infty$ 112° 40′; usual combinations ∞P . P, ∞$\breve{P}$2 . ∞P . P . $\breve{P}\infty$, and ∞P2 (*s*) . P (*o*) . $\breve{P}\infty$ (*d*) (fig. 158). The crystals are generally long prismatic, vertically striated and attached. It also occurs in radiated columnar or fibrous masses, rarely granular. Cleavage, in several directions all imperfect; fracture conchoidal or uneven; brittle; H. = 5·5 — 6; G. = 3·9 — 4·2. Opaque, resinous or imperfect metallic; colour brownish or greenish-black; streak black. B.B. fuses easily to a black magnetic globule; with borax to a dark-green glass. Soluble in hydrochloric acid, forming a yellow jelly. Chem. com. $\dot{Fe}^2\,\ddot{Si} + 3\,\dot{Fe}^2\,\ddot{Si} + \dot{Ca}^3\,\ddot{Si}^2$, or 28·8 silica, 24·8 iron peroxide, 33·4 iron protoxide, and 13·0 lime. Analyses.

Fig. 158.



	Silica.	Iron perox.	Iron prot.	Mang. prot.	Lime.	Alumina.	Watr.	Total.	
1	30·0	57·5	...	...	12·5	...	...	100·00	Vauquelin, Elba.
2	28·0	55·0	...	3·0	12·0	0·3	...	98·6	Collet-Descotils, Do.
3	29·28	...	52·54	1·59	13·78	0·61	1·27	99·07	Stromeyer, Do.
4	29·28	23·00	31·90	1·59	13·78	0·61	1·27	101·43	Do. cor. by v. Kobell, Do.
5	29·83	...	52·68	1·51	12·44	...	1·60	98·06	Rammelsberg, Do.
6	34·60	42·38	15·78	0·28*a*	5·84	0·12	1·00	100·00	Wehrle, Hungary.

(*a*) Peroxide.

In other trials Rammelsberg found the

Iron protoxide	=	30·73	... 33·074
Iron peroxide	=	24·58	... 22·800

and calculates the proportion as 33·06 to 24·56. He also found no alumina, and considered the water as merely hygroscopic.

Liëvrite occurs in beds among the crystalline strata along with tremolite, quartz, magnetic ironstone, copper pyrites, and other ores. It was first found in Elba in Monte Fico or Rio la Marina. Also near Fossum in Norway, Kupferberg in Silesia, Rhode Island in North America, and in Greenland. It was named Yenite in commemoration of the battle of Jena in 1806; Ilvaite from Elba, and Liëvrite from its discoverer Le Liévre.

Wehrlite, v. Kobell (No. 6); iron-black, with greenish-grey streak; slightly magnetic, and B.B. difficultly fusible; seems a variety of Liëvrite. It is found near Szurraskö in Hungary, with brown iron ore, probably as a vein in greenstone.

176. HISINGERITE, *Berzelius*, *Mohs*; Thraulite, *v. Kobell.*

Massive and reniform, with rough surfaces; or compact in concentric crusts. Fracture conchoidal; brittle; H. = 3·5 — 4; G. = 2·6 — 3. Opaque; resinous; colour brownish or bluish-black; streak liver or yellowish-brown; in the closed tube yields water. B.B. on charcoal fuses with difficulty to a steel-grey or black magnetic bead. Soluble in acids, leaving slimy silica. Chem. com. perhaps $\dot{F}\ddot{e}\,\ddot{s}i + 4\,\dot{H}$, if the iron all the peroxide. Analyses.

	Silica.	Alumina.	Iron protoperox.	Mang. perox.	Watr.	Total.	
1	27·50	5·50	51·50*a*	0·77	11·75	97·00	Berzelius, Gillinge.
2	36·30	...	44·39	...	20·70	101·39	Hisinger, Riddarhyttan.
3	31·77	...	49·87	...	20·00	101·64	Do. Bodenmais.
4	31·28	...	49·12	...	19·12	99·52	v. Kobell, Do.

(*a*) Peroxide.

Occurs in cavities of calc-spar in the iron mine of Gillinge in Sudermanland, and at Rydarhyttan in Sweden; and with magnetic pyrites at Bodenmais in Bavaria (thraulite). The *Polyhydrite* of Breithaupt, from Breitenbrun Saxony, seems also this rather rare mineral.

177. ANTHOSIDERITE, *Hausmann.*

Massive, in fine fibrous, flower-like aggregates; very tough; H. = 6·5; G. = 3. Opaque, or in thin fragments translucent; silky lustre; colour ochre-yellow to yellowish-brown. B.B. becomes reddish-brown, then black, and fuses with difficulty to a black magnetic slag. Soluble in hydrochloric acid. Chem. com. $\ddot{F}\ddot{e}\,\ddot{s}i^4 + \dot{H}$. Analyses, next page.

	Silica.	Iron perox.	Watr.	Total.	
1	61·14	34·63	3·59	99·36	Schnedermann.
2	59·03	35·35	3·59	97·97	Do.

Occurs in beds of magnetic iron at Antonio Pereira in Minas Geraes, Brazil.

178. Nontronite, *Berthier.*

Massive, or in nodules. Fracture uneven splintery. Soft; G. = 2·08. Opaque, but in water becomes partially translucent, the air being evolved in globules. Lustre dull or glimmering. Streak resinous. Colour straw-yellow, yellowish-white, or siskin-green. B.B. decrepitates, then becomes yellow, brown, and lastly black, and magnetic, but without fusing. Soluble; and gelatinizes in warm acids. Chem. com. nearly $\dddot{Fe}\,\ddot{S}i^3 + 5\,\dot{H} = 43$ silica, 36 iron peroxide, and 21 water. Analyses.

	Silica.	Alumina.	Iron perox.	Watr.	Magnesia.	Clay.	Total.	
1	44·0	3·6	29·0	18·7	2·1	0·1	97·5	Berthier, Nontron, Dordogne.
2	40·68	3·96	30·19	23·00	2·37	...	100·20	Dufrénoy, Villefranche.
3	41·31	3·31	35·69	18·63	...	... *a*	100·03	Jacquelin, Montmort.
4	41·10	...	37·30	21·56	...	0·1	99·96	Biewend, Autun.

(*a*) + 0·19 lime, and 0·90 copper protoxide.

179. Pinguite, *Breithaupt.*

Massive; fracture flat conchoidal, or uneven and splintery. Very sectile; H. = 1; G. = 2·3 — 2·35. Opaque or semitranslucent. Glimmering resinous lustre. Colour siskin or dark oil-green. Streak lighter. Feels very greasy; does not adhere to the tongue. In the closed tube yields much water. B.B. fuses only on the edges. With salt of phosphorus gives colour of iron, and leaves silica. Soluble in hydrochloric acid, depositing siliceous powder. Chem. com. $2\,\dddot{Fe}\,\ddot{S}i^2 + \dot{F}e\,\ddot{S}i^2 + 14\,\dot{H}$. The following is the analysis of a specimen from Wolkenstein, by Kersten:—36·90 silica, 29·50 iron peroxide, 6·10 iron protoxide, 0·45 magnesia, 1·80 alumina, 0·15 manganese peroxide, 25·10 water (= 100).

Occurs in veins of heavy spar in gneiss, at Wolkenstein and Geilsdorf in Saxony. Also found near Elbingerode in the Harz, in the basalt of the Pflasterkaute, at Tannhof near Zwickau, and at Suhl in the Thüringer Wald.

180. Chloropal, *Bucholz.*

Massive. Fracture conchoidal; rather brittle. H. = 2·5 — 3;

G. = 2·1 — 2·2. Translucent on the edges; lustre dull or glimmering; colour siskin or pistacio-green; streak lighter and glistening. B.B. infusible, but becomes first black, then brown, and shows reaction for iron with fluxes. Partially soluble in hydrochloric acid. Analyses.

	Silica.	Iron perox.	Magnesia.	Alumina.	Watr.	Total.	
1	46	33	2	1	18	100	Brandes, Unghwar.
2	45·00	32·00	2·00	0·75	20·00	99·75	Do. Do.
3	41·10	37·30	...	...	21·56	99·96	Biewend, Andreasberg.

Found in Hungary with semiopal, and in the Harz. It showed also traces of potash, and in No. 1 of manganese peroxide. From its action before the blow-pipe, the iron is probably the protoxide, and chem. com. $\dot{F}e^2\,\dot{S}i^3 + 4\,\dot{H}$.

181. CHLOROPHÆITE, *Macculloch, &c.*

Massive and disseminated. Apparent cleavage in two directions. Fracture conchoidal, earthy. Very soft and sectile. G. = 2·02. When first exposed, translucent, and pistacio or olive-green; but soon changes to brown or black, and becomes opaque. B.B. melts to a black glass. With borax gives colour from iron. Chem. com. $(\dot{F}e, \dot{M}g)^3\,\dot{S}i^4 + 18\,\dot{H}$. The following is the analysis of a specimen from Faroe, by Forchhammer:—32·85 silica, 22·08 iron protoxide, 3·44 magnesia, and 41·63 water (= 100).

Discovered by Dr Macculloch in the amygdaloidal trap of Scuir More in Rum. Since found at Qualboe on Suderoe in Faroe, and in Iceland. Also in Fife, and near Newcastle; and in America at Gill in Massachusetts, and Southbury in Connecticut.

182. THORITE, *Berzelius.*

Massive; fracture conchoidal, hard and brittle. G. = 4·63 — 4·8. Opaque, rarely translucent on the edges; splendent vitreous; reddish-brown, or black clouded with red; streak dark-brown. In the closed tube gives water, and becomes brownish-red. B.B. infusible; with salt of phosphorus leaves silica; with soda on platina wire shows reaction for manganese. Gelatinizes with hydrochloric acid. Chem. com. essentially $\dot{T}h^2\,\dot{S}i + 2\dot{H}$ = 73·4 thorina, 16·8 silica, and 9·8 water, but combined with very many other silicates. Analysis by Berzelius, 18·98 silica, 57·91 thorina, 2·58 lime, 3·40 iron peroxide, 2·39 manganese peroxide, 0·36 magnesia, 1·61 uranium oxide, 0·80

lead oxide, 0·01 tin oxide, 0·14 potash, 0·10 soda, 0·06 alumina, 9·50 water, and 1·70 undissolved mineral (= 99·54).

In this mineral Berzelius discovered the metal thorium. It is found in the island Löwö near Brevig in Norway, imbedded in syenite or compact analcime, and invested with a brown crust.

183. EULYTINE, *Breithaupt;* Kieselwismuth, *Naumann;* Silicate of Bismuth, *Thomson;* Bismuth Blende, *Dana;* Dodecahedral Diamond Blende, *Mohs.*

Tesseral and tetrahedral; usual forms $\frac{202}{2}$ and $-\frac{202}{2}$ with other faces. The crystals (sometimes like fig. 12, p. 13) are very small, often with curved faces, and attached singly or united in small druses and spherical groups. Cleavage, dodecahedral very imperfect; fracture conchoidal. H. = 4·5 — 5; G. = 5·9 — 6. Transparent and translucent; adamantine; clove or yellowish-brown, yellowish-grey or white. Streak white or grey. B.B. fuses readily with intumescence to a brown bead, leaving a yellow ring on the charcoal; with soda gives metallic bismuth; with salt of phosphorus leaves silica. Decomposed by hydrochloric acid, forming gelatinous silica. Chem. com. probably $\dot{B}i\ \dot{S}i^2$ with some phosphate of iron. Analyses.

	Silica.	Bism. perox	Phos. acid.	Iron perox	Mang. perox	Watr.	Fluor. acid.	Alumina.	Total.	
1	22·23	69·38	3·31	2·40	0·30	1·01*a*	1·37*b*	...	100	Kersten (m. of 2.)
2	50·24	13·03	9·62	10·54*c*	trace	...	...	14·65	98·08	Schüler.

(*a*) With fluoric acid; (*b*) with loss; (*c*) protoxide.

Found with quartz and bismuth at Schneeberg, and also at Bräunsdorf near Freiberg. No. 2 is the *Hypochlorite* of Schüler, or *Green iron-earth*, also from Schneeberg. It forms crypto-crystalline reniform crusts, or very fine, almost compact, earthy aggregates, semi-translucent or opaque; dull, and siskin or olive-green. H. = 6; G. = 2·9 — 3. B.B. infusible, but becomes blackish-brown; and forms a yellow ring on the charcoal. Insoluble in acids. It seems a mixture of silicate of iron and bismuth, with phosphate of alumina.

184. GADOLINITE, *Ekeberg, Phillips, Hauy;* Hemiprismatic Melan-ore, *Mohs.*

Monoclinohedric; according to Scheerer P∞ 49°, ∞P 115°, (2P∞) 70¾° nearly. The crystals, rare and indistinct, seem a combination of these forms, and appear prismatic from prevalence of ∞P. Chiefly massive and disseminated. Cleavage very indistinct or imperceptible. Fracture conchoidal, or uneven and splintery. H. = 6·5;

G. = 4·0 — 4·4. Opaque or translucent on the edges. Lustre vitreous, often resinous. Colour pitch-black or greenish-black; streak greenish-grey. Sometimes magnetic. B.B. the conchoidal (vitreous) varieties incandesce vividly, intumesce but do not fuse; the splintery varieties form cauliflower-like ramifications, but do not incandesce. Some fuse difficultly on thin edges. Gelatinizes in hydrochloric acid. Chem. com. very uncertain, but generally $\dot{R}^3\,\ddot{S}i$, in which $\dot{R}$ is yttria, protoxide of iron, protoxide of cerium, or glucina in various proportions. Analyses.

	Silica.	Yttria	Cerm. prot.	Iron prot.	Mag. nesia.	Lime.	Glucina.	Watr. &c.	Total.	
1	25·80	45·00	16·69	10·26	...	...	...	0·60*b*	98·35	Berzelius, Finbo.
2	24·16	45·93	16·90	11·34	...	...	...	0·60*b*	98·93	Do. Broddbo.
3	29·18	47·30	3·40*a*	8·00*a*	1·30*c*	3·15	2·00	5·20	99·53	Do. Kararfvet, Fahlun.
4	24·33	45·33	4·33*a*	13·59*a*	tracec	...	11·60	0·99	100·17	Thomson.
5	24·65	45·20	4·60*a*	14 55*a*	...	...	11·05	0·50	100·55	Richardson.
6	27·00	36·50	14·33*a*	14·50*a*	...	0·50	6·00	...	98·83	Connell.
7	25·59	44·96	6·33*d*	12·13	...	0·23	10·18	...	99·42	Scheerer, Hitterön.
8	24 65	49·60	7·64*f*	15·03	tracec	0·46	2·13	...	99·51	Berlin, Ytterby.
9	24·65	51·38	7·99*f*	14·69	1·29*e*	...	trace	...	100·00	Do. Do.
10	24·86	48·32	7·41*f*	14·80	0·67*e*	0·67	3·50	...	100·23	Do. Do.
11	24·85	51·46	5·24*f*	13·01	1·11*e*	0·50	4·80	..	100·97	Do. Do. (G. = 4·22).

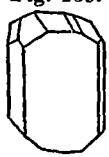
(*a*) Peroxide; (*b*) volatile matter; (*c*) manganese peroxide (*d*) Lanthanium oxide; (*e*) magnesia and protoxide of manganese; in 9 also with lime; (*f*) peroxide of cerium and lanthanium.

There are several other analyses of this mineral. Of the Ytterby varieties, Nos. 8, 9, 10 intumesced B.B. with weak or no incandescence; No. 11 incandesced strongly. According to H. Rose, the incandescence in gadolinite, and probably in other minerals, is caused by the liberation of specific heat, the quantity in the mineral before and after ignition being different. The crystallization of gadolinite has not been well ascertained. It is named from Gadolin, who, in 1794, found a new earth in it, named Yttria by Ekeberg in 1797. It occurs chiefly in granitic rocks in gneiss, as near Krageroe in Norway, both massive and crystallized (in the form described by Phillips, with ∞P (M) 118° nearly, and ∞P to P ($M : b$) 156°). At Ytterby in flesh-red felspar with Yttrotantalite; and at Finbo in granite veins with albite and quartz. It is also said to occur at Disko in Greenland, and in Ceylon.

185. ALLANITE, *Thomson;* Cerin, *Hisinger;* Orthite, *Berzelius;* Tetartoprismatic, and Prismatoidal, Melan-Ore, *Mohs.*

Rhombic, according to G. Rose and Scheerer; ∞P 128°, $\bar{P}\infty$ 110°, $2\,\bar{P}\infty$ 70°; distinct crystals rare (fig. 159), mostly in long needle-

Fig. 159.



shaped or columnar masses, intimately united and indistinctly formed; or granular and compact. Cleavage (along ∞P ?) imperfect; fracture conchoidal or uneven. H. = 6; G. = 3·2 — 3·7. Opaque, or slightly translucent in thin splinters. Lustre imperfect metallic, inclining to vitreous or resinous. Colour, black inclining to green or brown; streak greenish or brownish-grey. B.B. frothes, and melts easily to a black or brown scoria (glass, *v. Kobell*), often magnetic. Gelatinizes with hydrochloric acid. Chem. com. very variable, but, according to Scheerer, generally $3\dot{R}^3\ddot{S}i^2 + 2\ddot{R}\ddot{S}i$, in which $\dot{R}$ includes the protoxides of cerium, lanthanium, iron, and manganese, with lime, yttria, and magnesia; $\ddot{R}$ chiefly alumina, with some peroxide of iron. Analyses.

	Silica.	Alumina.	Cerium prot.	Lanthanium oxide.	Iron prot.	Mang. prot.	Lime.	Yttria	Magnesia.	Water &c.	Total.	
1	35·4	4·1	31·5	...	22·8	...	9·2	...	...	4·00	107·0	Thomson.
2	33·02	15·23	21·60	...	15·10	0·40	11·08	...	...	3·00	99·43	Stromeyer.
3	35·15	16·23	13·34	5·80	15·55	0·98	12·02	...	0·78	0·50	100·35	Scheerer.
4	34·09	16·40	13·73	7·80	15·51	...	11·75	...	0·56	...	99·75	Do.
5	30·17	11·31	26·19	...	20·72	...	9·12	...	...	...*a*	100·38	Hisinger.
6	32·06	6·49	23·80	2·45	25·26*b*	...	8·08	...	1·16	0·60	99·90	Scheerer.
7	36·25	14·00	17·39	...	11·42	1·36	4·89	3·80	...	8·70	97·01	Berzelius.
8	32·00	14·80	19·44	...	12·44	3·40	7·84	3·44	...	5·36	98·72	Do.
9	34·93	14·26	21·43*c*	...	14·90	0·85	10·42	1·91	0·86	0·52	100·08	Scheerer.
10	32·77	14·32	17·70	2·31	14·76	1·12	11·18	0·35	0·50	2·51*d*	98·28	Do.
11	33·81	13·04	20·50	...	15·65*e*	...	9·42	1·45	0·38	3·38*f*	98·30	Do.
12	32·93	15·54	20·01*g*	...	4·21	0·39	6·76	0·59	2·15	17·55*h*	100·13	Bahr.
13	33·05	15·29	20·55*g*	...	16·64	1·28*i*	10·19	1·18	...	1·24*k*	99·71	Berlin.
14	27·59	16·14	11·75*g*	...	16·01	1·55	2·28	2·12	4·94	11·46*k*	100·55	Do.
15	35·49	18·21	10·85	6·54	13·03	2·37*b*	9·25	—	2·06	2·00	99·80	Hermann.

(*a*) + 0·87 copper protoxide; (*b*) peroxide; (*c*) with lanthanium; (*d*) + 0·76 potash; (*e*) iron and manganese protoxide; (*f*) + 0·67 potash, and traces of zirconia and titanic acid; (*g*) with lanthanium and didymium; (*h*) water and carbonic acid; (*i*) with magnesia; (*k*) + 6·71 carbonic acid, and traces of copper, lead, and uranium.

From (1) Alluk, Greenland; (2) Iglorsoit, Do.; (3) Jotun-Fjeld; (4) Snarum; (5) Bastnaes mine at Riddarhyttan in Westmanland; (6) Riddarhyttan; (7) Finbo; (8) Gottliebsgang; (9) Fille-Fjeld; (10) Hitteröen, Norway, G. = 3·5; (11) Do., G. = 3·375, probably decomposed; (12) Eriksberg, Stockholm, yellow, G. = 2·78; (13) Thiergarten, Stockholm, G. = 3·41; (14) Kullberg, Stockholm, black, G. = 2·88; when dissolving evolves sulphuretted hydrogen, and, from the varying results of other trials, seems a mixture; (15) Ilmen mountains.

Nos. 1–4 are of Allanite, 5, 6 of Cerin, and 7–14 of Orthite. They prove the intimate union of these minerals, which Scheerer has shown also possess the same crystalline forms. Allanite was brought from Greenland by Giesecke, and named from the distinguished Edinburgh mineralogist. It occurs imbedded in granite; and has since been found in a similar position along with gadolinite at Hitteroe; on the Jotun Fjeld in massive albite; and at Snarum with albite, quartz,

hornblende, and apatite. Cerin occurs with copper pyrites and cerite at Rydderhyttan. Orthite at Finbo, and other places in Sweden, in granite or granitic gneiss; and massive, or in prismatic crystals in granitic masses in several mines near Arendal and Krageroe. The quarz and felspar enclosing orthite have often a reddish-brown colour, and appear to radiate from it as a centre.

The *Pyrorthite*, Berzelius, seems only this mineral mixed with carbonaceous and other matter. *Ural-orthite* of Hermann, No. 15, from the Ilmen mountains, differs chiefly in containing more alumina.

186. TSCHEWKINITE, *G. Rose.*

Massive, or amorphous. Fracture flat conchoidal; H. = 5 — 5·5; G. = 4·5296 (H. Rose). Nearly opaque; lustre vitreous, splendent. Colour velvet-black; streak dark-brown. B.B. intumesces greatly, becomes porous, and often incandesces. In the strongest white heat fuses to a black glass (with G. = 4·717). Gelatinizes with warm hydrochloric acid. Analyses.

	Silica.	Titanic acid.	Lime.	Magnesia.	Mang. prot.	Iron prot.	Cerium.	Alumina.	Potash & Soda.	Total.	
1	21·04	20·17	3·50	0·22	0·83	11·21	47·29 *a*	...	0·12	104·38	H. Rose.
2	34·90	1·65	7·10	1·30	2·85*b*	20·65	9·45 *c*	11·45	...	99·23	Choubine.
3	33	...	10	...	...	18	...	18	...		Ulex.

(*a*) Peroxides of cerium, lanthanium, and didymium; (*b*) peroxide; (*c*) cerium protoxide + 6·90 lanthanium peroxide, 0·95 yttria, and 2·00 water.

Found in the Ilmen mountains near Miask in granite. H. Rose's analysis is the mean of six, in which, however, all the constituents were not always determined. In No. 1 the excess arises from the cerium, which in the mineral is the protoxide; and the titanic acid also contained glucina, alumina, and yttria. Choubine seems to have analysed a different mineral, as Berzelius thinks orthite mixed with tschewkinite. Ulex also analysed it for allanite, and agrees more nearly with Choubine. A perfect analysis will only be possible when some method is discovered of separating the cerium from the substances associated with it (Rammelsberg).

187. CERITE, *Hisinger*, *Phillips;* Cererite, *Klaproth;* Cerinstein, *Werner;* Uncleavable Cerium-ore (Cerer-Erz), *Mohs.*

Hexagonal, according to *Haidinger;* crystals 0P . ∞P, in low, regular, six-sided prisms, but very rare. Generally massive, in fine granular, almost compact, aggregates. Cleavage, only traces; fracture uneven splintery; brittle. H. = 5·5; G. = 4·9 —5. Translucent on the edges, or opaque. Lustre dull, adamantine, or resinous.

Colour clove-brown to cherry-red or pearl-grey. Streak white. B.B. infusible, but becomes a dirty yellow; with borax in ox. flame forms a dark-yellow glass, becoming paler on cooling; and in red. flame nearly colourless. Soluble in hydrochloric acid, leaving gelatinous silica. Chem. com. $\dot{C}e^2\ddot{S}i + 2\dot{H}$, but the cerium includes also didymium and lanthanium. Analyses.

	Silica.	Cerium protox.	Lanth. perox.	Iron perox.	Lime.	Watr.	C abon. acid.	Total.	
1	34·50	50.75	...	3·50	1·25	5·00	...	95·00	Klaproth.
2	17	67	...	2	2	12*a*	...	100	Vauquelin.
3	18·00	68·59	...	2·00	1·25	9·60	...	99·44	Hisinger.
4	16·06	26·55	33·38	3·53	3·56	9·10	4·62 *b*	98·75	Hermann.

(*a*) With carbonic acid; (*b*) + 1·68 alumina, 0·27 manganese peroxide, and trace of copper.

Found only in the Bastnaes copper mine near Ridderhyttan in Sweden, with allanite, asbestus, and various ores. The cerium oxide is a mixture of several metals. Rammelsberg and Berzelius state that Hermann's specimen was mixed with calc-spar, and that the pure cerite contains no carbonic acid. Hermann considers the mineral analysed by Klaproth a distinct species, which he names *Ochroite*; but more probably it was cerite mixed with quartz.

188. PYROCHLORE, *Wöhler*; Octahedral Titanium-ore, *Mohs*. Tesseral; O, rarely with subordinate faces of ∞O or $2O2$. Occurs imbedded in crystals or grains. Cleavage, octahedral scarcely perceptible. Brittle; fracture conchoidal; H. = 5; G. = 3·8—4·3. Opaque or translucent. Lustre resinous; colour dark reddish-brown, or almost black, some crystals ruby-red and transparent. Streak pale-brown. B.B. becomes yellow and fuses with much difficulty into a blackish-brown scoria; with borax in ox. flame a reddish-yellow glass; in red. flame a dark-red glass. The fine powder soluble in concentrated sulphuric acid. Chem. com. very complex, but Miask variety $2\dot{R}^2\ddot{T}\ddot{a} + Na\ddot{F}$, where $\dot{R}$ is chiefly lime, thorina, and oxide of cerium. Analyses, next page.

The above analyses show very discordant results, and the tantalic acid is probably mixed with niobic and pelopic acid. No. 1 is from Miask in Ural, G. = 4·320, G. Rose; No. 2 from Brevig, Norway, G. = 3·802 (?). No. 3, also from Miask, G.=4·203, differs from No. 1 chiefly in containing no thorina, but zirconia and lithia. Wöhler by new experiments has confirmed the presence of thorina, and Berzelius agrees with him. No. 4 is from Fredriksvärn, Norway, but differs much from the former. Pyrochlore occurs in the places just mentioned. The *Ostranite* of Breithaupt, found with pyrochlore in the

	Tantalic acid.	Thorina and cerium perox.	Yttria	Iron prot.	Mang. prot.	Lime.	Sodium.	Fluorine.	Watr.	Total.	
1	67·38	13·15	0·81	1·29	0·15	10·98	3·93	3·23	1·16*a*	102·08	Wöhler.
2	67·02	5·16	4·66*b*	1·33	1·06	9·88	...	1·69	7·06*a*	97·80	Do.
3	62·25	3·32*d*	0·70*c*	5·68*c*	...	13·54	3·72*f*	indet.	0·50*g*	99·51	Hermann.
4	53·10	...	20·20*h*	2·35*c*	1·20*i*	19·45	...	...	0·80*k*	97·10	Hayes.
5	75·70	...	7·42*l*	...	...	14·84	...	...	2·04	100	Shepard.
6	79·60	...	...	0·99*c*	2·21*m*	10·87	...	...	...	95·97	Hayes.

(*a*) + titanic acid, magnesia, tin oxide in small undetermined amount; (in No. 2) also soda (?); (*b*) uranium oxide; (*c*) peroxide; (*d*) cerium peroxide; (*e*) with manganese peroxide; (*f*) potash, soda, and lithia; (*g*) + 2·23 titanic acid, 5·57 zirconia, 2·00 lanthanium oxide, and a trace of tungstic acid; (*h*) titanic acid; (*i*) oxides of uranium, manganese, lead, and tin; (*k*) volatile; (*l*) with tungstic acid and uranium protoxide; (*m*) peroxide of uranium and manganese; + 1·60 lead, and 0·70 tin.

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syenite, near Brevig, is thought identical, but forms small low rhombic prisms, clove-brown, and very similar to zircon.

Microlite of Shepard from Chesterfield in Massachusetts (Nos. 5, 6), agrees in external characters with pyrochlore; and is considered such by Dana and Teschemacher. Berzelius thought it yellow yttrotantalite.

189 OERSTEDTITE, *Forchhammer.*

Tetragonal; P 84° 26′, usual combination P . ∞P . ∞P∞ with other faces. H. = 5·5; G. = 3·629. Opaque or translucent on the edges; lustre adamantine vitreous; colour reddish-brown. In the closed tube gives water. B.B. infusible. In borax forms with difficulty a colourless glass. Forchhammer found in his analysis 19·71 silica, 2·61 lime, 2·05 magnesia, 1·14 iron protoxide, 68·96 titaniate of zirconia, 5·53 water (= 100).

Occurs at Arendal, imbedded singly in calc-spar or in granite (attached to augite, *Forchhammer ?*). The conformity of its crystallization and mode of occurrence to that of zircon, with such diversity in physical and chemical characters, except in both containing zirconia, is very remarkable.

190. KEILHAUITE, *Erdmann;* Yttrotitanite, *Scheerer.*

Massive; cleavage in one direction perfect, in two others traces. H. = 6 — 7; G. = 3·69. Translucent; lustre vitreous on the cleavage planes, resinous on the fracture. Colour blackish-brown; by transmitted light reddish. Streak greyish-brown. B.B. fuses easily with effervescence to a black shining slag. In borax forms a glass coloured by iron, which in red flame becomes blood-red. With salt of phosphorus leaves silica, and forms a violet-glass in the inner

flame. With soda shows reaction for manganese. In powder soluble in hydro chloric acid Analyses.

	Silica.	Lime.	Iron perox.	Alumina.	Mang. perox.	Cerium oxide.	Titanic acid.	Yttria	Total.	
1	30·00	18·92	6·35	6·09	0·67	0·32	29·01	9·62	100·98	A. Erdmann.
2	29·45	18·68	6·48	5·90	0·86	0·63	28·14	9·74	99·88	Do.

Erdmann gives the formula $(3\,\dot{C}a^3\,\ddot{S}i^2 + \ddot{R}\,\ddot{S}i) + \dot{Y}\,\ddot{T}i^3$. Found imbedded in granite at Buö, and in greenish-grey massive scapolite in the Nas mine, near Arendal. It much resembles common garnet, but may be distinguished by its specific gravity.

191. Wöhlerite, *Scheerer.*

Occurs in indistinct tabular crystals, or in prisms with six or eight sides, and strongly striated; also massive in angular grains. Cleavage in one direction perfect; fracture conchoidal; H. = 5 — 6; G. = 3·41. Translucent; vitreous or resinous; colour yellow, inclining to red or brown. B.B. fuses to a yellowish glass; with fluxes shows reaction for manganese, iron, and silica; easily soluble in warm concentrated hydrochloric acid, depositing silica and tantalic (niobic) acid. Analysis by Scheerer, 30·62 silica, 14·47 tantalic (niobic) acid, 15·17 zirconia, 2·12 iron peroxide, 1·55 manganese protoxide, 26·19 lime, 0·40 magnesia, 7·78 soda, 0·24 water (= 98·54).

Found imbedded in the zircon syenite near Fredriksvärn and Brevig in Norway. Scheerer now considers the substance named tantalic acid in his analysis to have been niobic acid.

192. Polymignite, *Berzelius;* Prismatic Melan-ore, *Mohs.*

Rhombic, P with polar edges 136° 28′ and 116° 22′, ∞P 109° 46′. The crystals formed by $\infty\breve{P}\infty$. $\infty\breve{P}\infty$. ∞P . P with other prisms are long, rather broad columnar, and vertically striated. Cleavage, macrodiagonal imperfect, brachydiagonal scarcely perceptible; fracture conchoidal; H. = 6·5; G. = 4·806. Opaque; lustre semimetallic; iron-black; streak dark-brown. B.B. infusible alone, or with soda; with borax forms a glass coloured by iron; soluble in concentrated hydrochloric acid. Chem. com. uncertain. Analysis by Berzelius, 46·30 titanic acid, 14·14 zirconia, 12·20 iron peroxide, 2·70 manganese peroxide, 5·00 cerium peroxide, 11·50 yttria, 4·20 lime (= 96·04).

Berzelius found also traces of potash, magnesia, silica, and oxide of tin. The loss arises from the difficulty of separating the titanic

acid and zirconia, and the small amount of the mineral. Hermann has examined it for tantalic acid, or similar substances, without success. It is found imbedded, or in small cavities, in the zircon syenite of Fredriksvärn in Southern Norway.

193. Polykrase, *Scheerer.*

Rhombic, in six-sided tables of the combination $\infty\breve{P}\infty . \infty P . P . 2\breve{P}\infty$ and other faces; with ∞P 140°, and the brachydiagonal polar edges of P 152°. Cleavage not observable; fracture conchoidal; H. = 5 — 6; G. = 5·0 — 5·15. Opaque, or in very fine splinters translucent yellowish-brown; colour black; streak greyish-brown. B.B. decrepitates violently, and when raised to a low red heat incandesces, and assumes a greyish-brown colour, but is infusible; with borax forms in the outer flame a yellow, in the inner a brown glass; slowly and imperfectly soluble in warm hydrochloric acid, wholly in sulphuric acid. Scheerer found that it contains titanic and tantalic acids, zirconia, yttria, iron peroxide, uranium oxide, cerium protoxide, with a little alumina, traces of lime, magnesia, and perhaps an alkali; but it is not quantitatively analysed. It differs from polymignite in containing tantalium and uranium, with no manganese, and very little lime. Found at Hitterö in Norway.

194. Perowskite, *G. Rose.*

Tesseral; in many forms, especially $\infty O\infty$, O, ∞O, several tetrakishexahedrons and icositetrahedrons, but generally cubes. Crystals small. Cleavage hexahedral; H. = 5·5; G. = 4. Opaque, or translucent on the edges (brown varieties); lustre adamantine; colour greyish or iron-black, or dark reddish-brown. B.B. infusible; with borax or salt of phosphorus shows reaction for titanic acid; slightly affected by acids. Chem. com. $\dot{C}a\,\ddot{T}i$, with 58·9 titanic acid and 41·1 lime. Analyses.

	Titanic acid.	Lime.	Magnesia.	Iron protox. with trace of manganese.	Total.	
1	58·96	39·20	trace	2·06	100·22	Jacobson (iron-black).
2	59·00	36·76	0·11	4·79	100·07	Brooks (dark brown).

Found in a bed of chlorite slate near Slatoust in the Ural.

195. Aeschynite, *Berzelius;* Aechynite, *Beudant.*

Rhombic; ∞P 127° 19′, $2\breve{P}\infty$ 73° 44′; usual combination $\infty P . 2\breve{P}\infty$, to which also $\infty\breve{P}\infty$, and sometimes P are joined. The crystals are long prismatic (fig. 160), generally very imperfectly formed,

vertically striated, and imbedded. Cleavage, macrodiagonal only in traces; fracture imperfect conchoidal; H. = 5 — 5·5; G. = 4·9 — 5·1. Opaque or dimly translucent on thin edges; lustre submetallic or resinous; iron black or brown; streak yellowish-brown; in the closed tube yields water, in the open tube traces of fluoric acid. B.B. swells, and becomes yellow or brown, but is infusible; with borax and salt of phosphorus shows reaction for titanium, and in red. flame gives with tin a red bead; not soluble in hydrochloric acid, partially in concentrated sulphuric acid. Analyses.

Fig. 160.

	Titanic acid	Niobic acid.	Zirconia.	Iron prot.	Cerium prot.	Lanthanium oxide.	Yttria	Lime.	Watr.	Total.	
1	56·0	...	20·0	2·6 *a*	15·0 *a*	... *b*	...	3·8	...	97·9	Hartwall.
2	11·94	33·39	17·52	17·65	2·48	4·76	9·35	2·40	1·56 *c*	101·05	Hermann.
3	10·56	35·05	17·58	4·32	15·59	11·13	4·62	...	1·66 *d*	100·51	Do. , G. = 4·95

(*a*) Peroxide; (*b*) + 0·5 tin oxide; (*c*) + traces of manganese, magnesia, tungstic acid, and fluorine; (*d*) with trace of fluorine.

Hermann suspects that the titanic acid of Hartwall's analysis contained niobic acid, as Berzelius has shown that the mineral he examined was undoubtedly the true aeschynite. The zirconia is of doubtful nature; it is not thorina, but perhaps the norium earth of Svanberg. Aeschynite occurs near Miask in the Ural, in a granular mixture of felspar, albite, and mica, along with zircon.

196. MENGITE, *G. Rose;* Ilmenite, *Brooke.*

Rhombic, P with polar edges 150° 32′ and 101° 10′, ∞P 136° 20′; the crystals, formed by ∞P. ∞P̆3 . ∞P̆∞ . P, are small, prismatic, and imbedded. Cleavage not observable; fracture uneven; H. = 5 — 5·5; G. = 5·48. Opaque; semi-metallic lustre; colour iron-black; streak chesnut brown. B.B. infusible, but becomes magnetic; forms a clear glass with borax and salt of phosphorus. Almost wholly soluble in warm concentrated sulphuric acid; scarcely affected by hydrochloric acid. Not analyzed, but contains zirconia, peroxide of iron, and perhaps titanic acid. It is found in granitic veins in the miascite of the Ilmen mountains. It was first described by Mr Brooke, but his name, ilmenite, was already appropriated to another mineral.

197. MONAZITE, *Breithaupt;* Mengite, *Brooke;* Edwardsite, Eremite, *Shepard.*

Monoclinohedric, C = 77°, ∞P 94° 35′; usual combination 0P . ∞P (∞P∞) . P∞ . —P∞, in which 0P : P∞ = 129° 6′, 0P : —P∞

Fig. 161.

$=139°\ 25'$ (fig. 161). Crystals thick, tabular, or very short prismatic; singly imbedded. Cleavage basal imperfect. H. = 5 — 5·5; G. = 5 — 5·25. Translucent on the edges; lustre dull resinous; colour flesh-red, hyacinth-red, and reddish-brown. B.B. infusible; moistened with sulphuric acid, colours the flame green. Soluble in hydrochloric acid. Analyses.

	Phosphoric acid.	Cerium prot.	Lanthan. oxide.	Thorina.	Tin oxide.	Mang. perox.	Lime.	Magnesia.	Total.	
1	28·50	26·00*a*	23·40	17·95	2·10	1·86	1·68	...*b*	101·49	Kersten, Ural.
2	29·05	37·36	27·41	...	1·75	...	1·46	0·80*c*	96·83	Hermann, Do.
3	17·94	49·35	21·30	...	...	...	1·50	...*d*	97·72	Do. Do.

(*a*) Peroxide; (*b*) + traces of potash and titanic acid; (*c*) + traces of manganese and iron; (*d*) + 6·27 substance like tantalium, 1·36 water, with traces of magnesia and iron peroxide.

Hermann's analysis chiefly differs from Kersten's in that he finds no thorina, which, however, both Wöhler and Berzelius affirm occurs in this mineral, and that he considers the cerium as the protoxide. The loss arose from the pounded mineral having been ignited in the open air, when it lost moisture and absorbed oxygen. The monazite is found in a granitic rock in the Ilmen mountains; the edwardsite, identified with it by G. Rose, along with sillimanite, at Norwich and Chester in Connecticut, and at Yorktown in New York. Shepard states that it contains thorina and lanthanium oxide, and regards the zirconia in his former analysis as arising in a mixture of zircon. No. 3 is the Monazitoid of Hermann, found with monazite, passing into it and crystallizing in the same forms, G. = 5·281, but distinguished by its brown colour. It is only partially soluble in acids, and B. B. incandesces strongly, but does not fuse.

198. SAMARSKITE, *H. Rose;* Uranotantalite, *G. Rose;* Yttroilmenite, *Hermann.*

Rhombic; isomorphous with columbite (Hermann?) mostly imbedded in flat, somewhat polygonal grains. Fracture conchoidal; brittle. H.= 5·5; G. = 5·625; opaque; strong semi-metallic lustre; velvet-black; streak dark reddish-brown. B.B. fuses on the edges to a black glass. Powder easily fused with borax in the inner flame to a yellow, in the outer to a yellowish-green glass, inclining to red when more of the flux is added. In the closed tube decrepitates, yields water, incandesces, and becomes brown. Soluble in hydrochloric acid with difficulty, but wholly to a greenish fluid. Analyses, next page.

Occurs in grains the size of a hazel nut or under in the miascite of the Ilmen mountains near Miask. It does not contain the tantalic

	Metallic acid.	Magnesia.	Lime & mang. protox.	Iron prot.	Uranium perox.	Yttria	Titan. acid.	Cerium prot.c	Total.	
1	56·38	0·80	0·92	15·43	14·16	9·15	...	...	96·84	v. Percz.
2	56·00	0·75	1·02	15·90	16·70	11·04	...	...	101·41	Do.
3	55·91	0·75	1·88	15·94	16·77	8·36	...	...	99·61	Do.
4	57·81	0·50a	0·31	13·61	1·87b	18·30	5·90	2·27	100·58	Hermann.

(a) Lime; (b) protoxide; (c) with lanthanium oxide.

acid of the Finnland minerals, but niobic and tungstic acids, sometimes with a trace of pelopium, and hence the original name was changed by H. Rose. In No. 1 some uranium was lost. Hermann once thought that No. 4 contained the acid of a new metal, which he named ilmenium, but the researches of H. Rose have shown that this is niobic, mixed with tungstic acid, and the mineral identical with samarskite. Hermann found a lower specific gravity, but this arose from employing the ignited mineral; as H. Rose observed a specimen of yttroilmenite to fall from G. = 5·703 before, to 5·454 in powder after ignition, and another of samarskite from 5·617 before, to 5·37 — 5·485 after, also in powder.

II. ORDER.—SALINE STONES.

I. Family.—Calc-spar.

199. Calc-spar; Calcareous spar; Carbonate of lime, *Phillips, Jameson, &c.*; Kalkspath, Kohlensaurer Kalk, *Werner, &c.*; Chaux carbonatée, *Hauy*; Rhombohedral Lime Haloid, *Mohs.*

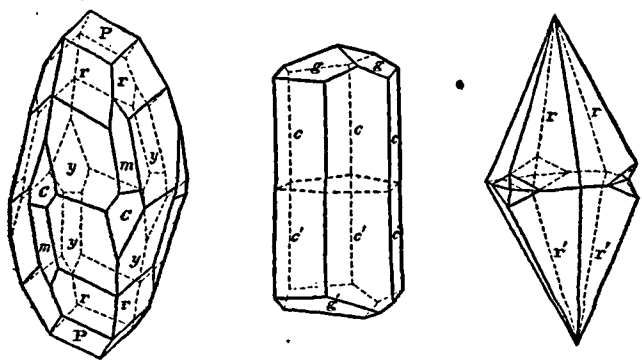
Rhombohedral, R 105° 3′ to 105° 18′, the most common variety being 105° 8′. The forms and combinations are exceedingly numerous. Among the more remarkable are the following, principally after Naumann.

More than thirty rhombohedrons, among which especially $-\frac{1}{2}R$ 135°, R, $-\frac{1}{4}R$ 95½°, $-2R$ 79°, and $4R$ 66° prevail, along with 0R and ∞R as very common limiting forms. More than fifty distinct scalenohedrons, the most frequent being R^3, R^2, and $\frac{1}{4}R^3$. The second hexagonal prism $\infty P2$ is also common, whilst hexagonal pyramids are among the rarer forms. Some of the most usual combinations are $\infty R \cdot -\frac{1}{2}R$, like the simple form fig. 163 below; or $-\frac{1}{2}R$.

∞R, very frequent; also ∞R . 0R, or 0R . ∞R; and likewise —2R . R; R^3 . ∞R; R^3 . ∞R . —2R; R^3 . $\frac{1}{4}R^3$; and many others, upwards of an hundred distinct combinations being known. Fig. 162 represents a more complex combination, or R^5 (*y*) . R^3 (*r*) . R (*P*) . 4R (*m*) . ∞R (*c*). The faces of the crystals are generally straight, but sometimes curved; 0R being frequently drusy or rough; —$\frac{1}{2}$R striated parallel to the clinodiagonal of its faces; whilst the scalenohedrons (R^n), and ∞P2, show a striation parallel to the middle edges of R.

Macles are not uncommon, united according to various laws; especially with the systems of axes parallel. The two individuals then

Fig. 162. Fig. 163. Fig. 164.



generally occur in juxtaposition, and very symmetrically formed,—only one half, the upper or under, of each existing, and the two united in the middle (fig. 163), as if a single crystal had been cut in two and one half turned round 180° on the common axis. Such macles are very frequent in crystals formed by R^3 and the associated combinations (fig. 164), and also by R, and then occasionally several times repeated. Other macles occur with the systems of axes inclined; some conjoined by a face of R with the chief axes almost at right angles to each other (fig. 86 above); and others more frequently conjoined by a face of —$\frac{1}{2}$R, in which the chief axes form an angle of 127$\frac{1}{2}$°. The latter macles, especially those of R, occur also in fragments of massive calc-spar, and usually many times repeated, the centre crystals being much shortened so as to appear in lamellae not thicker than paper (compare fig. 85, p. 42, above).

Polysynthetic crystals and groups of various kinds are very common, whilst granular and compact masses abound, forming whole

rocks or mountains. Less common are the columnar and fibrous varieties, and rarer still the thin foliated aggregates.

Cleavage, rhombohedric along R very perfect and easily obtained, so that the conchoidal fracture is rarely observable. Brittle; H. = 3; G. = 2·6 — 2·8; pure transparent crystals = 2·72. Pellucid in all degrees. Very distinct double refraction. Lustre generally vitreous, but several faces resinous, and 0R pearly, but usually dull. Most frequently colourless or white, but often grey, blue, green, yellow, red, brown, or black, in various shades. Streak greyish-white. B.B. infusible, but becomes caustic and emits a bright light; in other respects acts like pure lime. Effervesces, and is entirely soluble in hydrochloric or nitric acid. The fine powder ignited on platina-foil over the spirit-lamp, according to *v. Zehmen*, forms a somewhat connected mass, and even adheres to the platina. Chem. com. of the purest varieties, carbonate of lime $\dot{C}a\,\ddot{C}$, with 43·87 carbonic acid and 56·13 lime, or 40 calcium, 12·2 carbon, and 47·8 oxygen. Rammelsberg gives the following analyses of very pure and remarkable varieties.

	Lime.	Carbon acid.	Iron perox.	Mang. perox.	Watr.	Total.	
1	55·98	43·56	0·36		0·10	100	Stromeyer, Andreasberg.
2	56·5	43·0	...		0·5	100	Bucholz, Iceland spar.
3	56·15	43·70	0·15		...	100	Stromeyer, Do.
4	55·00	41·66	...	3·00	...	99·66	Do. Slaty spar, Schwarzenberg, Saxony.
5	55·30	43·52	...	... *a*	1·07	100·02	Schnabel, Brilon, Westphalia.
6	50·76	43·81	0·51 *b*	...	...	100	Gibbs, Zinc mines, Olkucz.

(*a*) + 0·13 magnesia; (*b*) protoxide of iron + 4·07 zinc oxide, and 0·85 magnesia.

Less pure varieties often contain a larger proportion of magnesia or of the protoxides of iron and manganese, which replace part of the lime, and occasion slight changes in the specific gravity, colour, and angular dimensions of the crystals. A specimen from a druse in the Calamine mines of Altenberg near Aix-la-Chapelle contained 89·27 carbonate of lime, 9·31 carbonate of iron, and 1·64 carbonate of zinc (= 100·22, *Monheim*).

This important mineral occurs in a great variety of forms, Count Bournon having described 700 kinds of crystals, Hauy 154, and Lévy 158 in Mr Heuland's collection, but many of these would probably prove identical on rigid criticism. It is found in the most diverse situations—in every geological formation, and every country on the globe. It seldom appears as a constituent of rocks with other minerals, but more often forms whole beds by itself, or traverses other rocks in veins, and in distinct, often lenticular, masses; or fills druses

and amygdaloidal cavities. Remarkable specimens of the crystallized variety, or proper calc-spar, are found in Andreasberg and other parts of the Hartz (six-sided prisms), Freiberg, Tharand, Maxen, Alston Moor in Cumberland (flat rhombic crystals), and in Derbyshire (pale yellow transparent pyramids, often of large dimensions). Mohs remarks the singular fact that certain simple forms and combinations prevail in particular localities and countries, whilst crystals of a different character appear in other regions. Thus in England, scalenohedrons, R^3, and combinations in which this forms a predominant part, chiefly prevail; in the Harz many rhombohedrons, with the limiting forms 0R and R∞, preponderate; in Bohemia and Saxony also rhombohedrons, as $-\frac{1}{2}R$, 4R, and their combinations with ∞R. Carinthia, the Bohemian Mittelgebirge, and the neighbourhood of Prague have, again, other peculiar groups of forms.

Certain varieties, distinguished by their structure or other properties, have received distinctive names. The Iceland spar, remarkable for its transparency and double refraction, is not found crystallized, but occurs massive in a trap rock in that island, and has been considered as a portion of altered limestone. The *Slate spar (Schiefer spar)* is the thin lamellar variety, often with a shining white, pearly lustre, and greasy feel. It is found in the county Wicklow in Ireland, in Glentilt in Scotland, and in Norway. The *Aphrite* from Hessia and Thuringia is a similar fine scaly variety. *Marble* is also a massive variety of this mineral, its crystalline texture having generally been produced by igneous action on compact limestone. Paros, Naxos, and Tenedos furnished the chief supply to the Grecian artists; Carrara near the Gulf of Genoa to those of modern times. The latter quarries are situated in a rock, the Macigno, probably not older than the cretaceous epoch—and that of Paros seems of the same date. Some of the coloured marbles of the ancients were impure limestones, as the *Cipollino* zoned with green talc or chlorite, the *Verde antique* mixed with green serpentine. The *Ruin marble*, when polished, shows irregular markings like ruins, and is common in the Val d'Arno (Florentine marble), and near Bristol (Cotham marble). The *Lucullite*, a black marble, was first brought by Lucullus to Rome from an island in the Nile; and other dark varieties, or *Anthraconite*, like that from Kilkenny in Ireland, have been used as ornamental stones. The *Lumachello*, from the lead mines of Bleiberg in Carinthia, is a limestone full of fossil shells, exhibiting beautiful iridescent colours, sometimes deep-red or orange, when it is designated Fire marble.

Limestone occurs in all formations, from the oldest to the most recent, under various geological names. The *Oolite*, egg or roe-stone, consists of round concretions, with a concentric laminar structure like

the roe of fish. *Pisolite* or peastone has a similar structure. *Chalk* is a soft earthy variety, too well known to need description; and *marl* is calcareous matter more or less mixed with clay. *Tufa* or calcareous tufa, generally a recent deposit from calcareous springs, has often a loose friable texture, but at other times is hard and compact; and in the neighbourhood of Rome forms the common building stone or Travertino. The sandstone of Fontainblean is carbonate of lime ($\frac{1}{3}$), mixed with quartz sand ($\frac{2}{3}$), and occasionally crystallizing in rhombohedrons.

This mineral is employed in many ways,—the impurer varieties, as lime, for mortar, manure, tanning, and similar purposes; the finer, as marbles, for sculpture, architecture, and ornamental stone-work; the chalk for writing, white-washing, or producing carbonic acid. Some varieties are used as a flux in melting iron and other ores, or in preparing glass. Compact limestone is seldom pure carbonate of lime, occasionally containing magnesia, considered hurtful to vegetation, oxide of iron or other metals, bitumen, carbon, and phosphoric acid, which, though only found in very minute proportions, is of great agricultural importance. The latter element is common in recent corals, and has been found in most limestones analyzed with sufficient accuracy.

In the blue limestone from Vesuvius Klaproth found 58·00 lime, 28·50 carbonic acid, 11·00 water, and 2·25 earthy mixtures (= 99·75): which gives 2 $\dot{C}a\,\ddot{C} + \dot{C}a\,\dot{H}^2$ or a combination of the carbonate with the hydrate of lime. Fuchs states that burnt lime forms a similar combination in the air.

The *Plumbocalcite*, Johnston, is either a mixture of carbonate of lime, with an isomorphous carbonate of lead, or a mineral very near to calc spar in form and properties. It has a rhombohedral cleavage (R 104° 53′), is white and pearly, softer than calc-spar, but of higher specific gravity (= 2·824). It consists of 92·2 carbonate of lime and 7·8 carbonate of lead, and has been found at Wanlockhead mines in Scotland.

200. DOLOMITE, *Werner, Jameson;* Bitter Spar, *Phillips;* Chaux carbonatée magnésifère, &c., *Hauy;* Dolomie, *Beudant;* Macrotype Lime-Haloid, *Mohs.*

Rhombohedric, R 106° 15′ — 20′. Far the most frequent form is R itself; also combinations of R and $-\frac{1}{2}$R, or others in which 0R, ∞R, and 4R appear. The rhombohedrons often have the faces more or less curved, and saddle-shaped; more rarely they are lenticular or spheroidal. The crystals sometimes imbedded singly, generally combined in druses; also in coarse or fine granular or compact masses, often cel-

lular and porous. Cleavage, rhombohedral along R; the planes often curved. H. = 3·5 — 4·5; G. = 2·85 — 2·95. Translucent; lustre vitreous, but often pearly or resinous; colourless or white, but frequently pale-red, yellow, or green. B.B. infusible, but becomes caustic, and often shows traces of iron and manganese. Fragments effervesce very slightly or not at all in hydrochloric acid; the powder is partially soluble, or wholly when heated. According to *v. Zehmen*, the very fine powder ignited on platina-foil for a few minutes over a spirit-lamp *continues* pulverulent, but intumesces slightly during ignition. Chem. com. generally $\dot{Ca}\,\ddot{C} + \dot{Mg}\,\ddot{C}$, with 54·3 carbonate of lime and 45·7 carbonate of magnesia; but other varieties give different or even indeterminate proportions. Analyses.

	Carb. of lime	Carb. of mag.	Carb. of iron pro.	Carb. of man. prot.	Total.	
1	73	25	...*a*	...	100·25	Klaproth, Taberg.
2	70·5	29·5	...	...	100	Do. Gurhof.
3	61·00	36·53	2·74	...	100·27	Rammelsberg, Kolozoruk.
4	56·66	38·60	3·30	1·70	100·26	Meitzendorf, Zillerthal.
5	51·00	44·32	4·68	...	100	Pelletier, Traversella (?) (G. = 2·629.)
6	85.84	10·39	5·53	...	101·76	Kühn, Kolozoruk, near Bilin.
7	61·30	32·20	6·27	...	99·77	Do. Bohemia, upper layer.
8	77·63	18.77	3·67	...	100·07	Do. Do. lower layer.
9	28·0	67·1	3·5	...	99·0	John, Meisner (Conite).
10	54·76	42·10	4·19	...	101·05	Kühn (Tharandite).
11	55·62	42·40	0·56	...	98·58	Rammelsberg? Ilfeld (Raubkalk).
12	75·87	24·52	...	...	100·39	Do.? Rappenau, Silesia, granular limestone.
13	56·88	40·47	2·81	...	99·16	Scheerer, Gulbrandsdal, Norway.
14	55·36	41·30	...	...*b*	99·16	Laugier, La Spezzia.
15	46·40	26·95	25·40	...*c*	99·50	Schweitzer, Tinzen in Graubündten.

(*a*) + 2·25 iron peroxide; (*b*) + 2·00 iron peroxide and 0·50 silica; (*c*) + 0·75 remainder.

Nos. 1–10 are crystallized, 11–14 massive dolomites or magnesian limestones. The proportion of carbonate of lime to carbonate of magnesia is in Nos. 4, 10, 11, 13, 14 nearly as 1 : 1; in Nos. 3, 7 as 3 : 2; in Nos. 1, 2 as 2 : 1; in Nos. 8, 12 as 3 : 1; in No. 6 as 4 : 1; and in No. 9 as 1 : 3; but the proportions are not exact, and more probably indefinite. No. 15, of a white colour, is remarkable for the amount of iron, and is rather an ankerite.

In a crimson red variety from Przibram in Bohemia, G. = 2·921, Gibbs found, on a mean of two trials nearly agreeing, 31·79 lime, 17·00 magnesia, 4·70 oxide of cobalt, 1·26 protoxide of iron, and 45·25 carbonic acid (= 100). This, according to Rammelsberg, gives $\dot{Ca}\,\ddot{C} + (\dot{Mg}, \dot{Co}, \dot{Fe})\,\ddot{C}$, and is the first instance of cobalt being found in this mineral, and the metal is in the state of a neutral carbonate, in which it is not known independently.

The diversity of its forms and composition, and its external resemblance in many cases to other species, has created considerable confusion in reference to this mineral, which has been increased by the

several varieties being often limited to certain localities. The massive, granular, sometimes easily divisible variety, of a white colour, has been named *dolomite;* a similar variety, but larger grained, or distinctly crystallized and cleavable, often with colours inclining to green, is the *rhomb* or *bitter-spar*, the *Rautenspath* and *Bitterspath* of the Germans; and a third, either in simple crystals or in imitative forms, of colours inclining to red or brown, and more distinct pearly lustre, is the brown-spar and pearl-spar of mineralogists. Many so-called brown-spars are, however, arragonite, other foliated, rose-red varieties, manganese-spar (diallogite), and others calc-spar. In general these minerals are most conveniently distinguished by the specific gravity.

Dolomite, or the massive varieties forming whole mountains, occurs especially in the Alps near St Gotthardt, on the Brenner in Tyrol, in Carinthia, near Baden in lower Austria, and in the Apennines. Crystallized specimens are common in Salzburg, Tyrol, and Switzerland. Rhombohedrons of considerable size, sometimes macled, are found with transparent quarz at Traversella in Piemont; and fine transparent specimens also at St Gotthardt and at Gap in France. Pearl-spar, in fine varieties, in the lead mines of Alston in Cumberland, in Derbyshire, and at Leadhills and Charlestown in Scotland. In North America, Roxbury in Vermont, Lockport near Niagara, and Rochester New York, furnish this mineral. A greenish macled variety is found at Miemo in Tuscany (*Miemite*), at Glücksbrun in Thuringia, and Tharand in Saxony (*Tharandite*). Rhombohedrons with convex faces occur in basalt at Kolosoruk near Bilin, in Bohemia, and a remarkable massive variety of oil-green colour and double granular structure at Rakovitza in Syrmia. The Gurhofian (No. 2), from Gurhof in lower Austria, is white and compact like semiopal.

The compact varieties or magnesian limestones are valued for mortar, being considered more durable than limestone. They often prove injurious when applied too soon after calcination to land. This rock is also valued as a building stone, the cathedral of Milan, York Minster, and the New Houses of Parliament being constructed of it. The Parian marble has been supposed to belong to this species from its specific gravity, and also the Iona marble in the Hebrides. Many geologists consider that dolomite has been produced by a metamorphic action of volcanic gases on common limestone; and the calcareous blocks ejected from Vesuvius are very similar in character. Other geologists have assigned a direct igneous origin to some masses of this rock; whilst many magnesian limestones like those in the

north of England are probably original deposits. The flexible limestone from near Sunderland is a magnesian rock.

The *Predazzite* of Petzholdt, which forms whole mountain masses at Predazzo in Tyrol, has a coarse or fine granular structure, a white colour, and vitreous lustre on the cleavage planes; H. = 3·5; G. = 2·623. Leonardi found 6·98 per cent. water, and in the remainder 68·7 carbonate of lime, 30·3 carbonate of magnesia, and 1·0 silica, alumina, and iron peroxide (= 100). It is probably merely a dolomite, or, according to Damour, a limestone, or common carbonate of lime, mixed with 35 per cent. hydrate of magnesia and 1 per cent. silica and protoxide of iron.

201. BREUNNERITE, *Haidinger*, *Phillips*; Talkspath, *Naumann*; Giobertite, *Beudant*; Brachytypous Lime-Haloid, *Mohs*.

Rhombohedral; R 107° 10′—30′; as yet only known in single imbedded crystals of the form R; and in granular or columnar aggregates. Cleavage, along R very perfect, with straight faces; H. = 4 — 4·5; G. = 2·9 — 3·1. Transparent or translucent on the edges. Lustre highly vitreous. Colourless, but often yellowish, brown, or blackish-grey. B.B. infusible, but generally becoming grey, or black and magnetic. With soda shows reaction for manganese. Soluble in acids, often only when pulverized and warmed. Chem. com. essentially carbonate of magnesia, $\dot{M}g\ \ddot{C}$, with 51·7 carbonic acid, and 48·3 magnesia, but often mixed with carbonate of protoxide of iron or manganese. Analyses.

	Carbonate of magnes.	Carbon. iron prot.	Carb. of manga. protox.	Total.	
1	89·70	8·02	2·44*a*	100·26	Stromeyer, Hall, Tyrol.
2	87·78	10·54	0·90	99·22	Do. St Gotthardt.
3	86·05	13·15	...	99·20	Brooke, Tyrol.
4	84·79	13·82	0·69	99·30	Stromeyer, Zillerthal.
5	84·36	10·02	3·195	100·00	Walmstedt, Harz.
6	82·91	15·59	1·19	99·69	Magnus, Pfitschthal.
7	82·89	16·97	0·78	100·64	Stromeyer, Fassathal.

(*a*) + 0·11 carbon; (*b*) + 1·62 carbon, 0·30 silica, 0·51 water.

These analyses show the variable composition of this mineral, and also its principal localities. It is said to occur at Unst in Zetland, imbedded in green foliated talc; and in North America.

The following two species can hardly be distinguished from the present, and the ankerite is closely related.

202. MAGNESITE, *v. Leonhard*; Compact Carbonate of Magnesia, *Phillips*; Magnésie carbonatée, *Hauy*.

Amorphous or cryptocrystalline, as yet only reniform or massive, surface rough or fissured. Fracture conchoidal or uneven; H. =

3 — 5; G. = 2·85 — 2·95. Sub-translucent or opaque. Lustre dull; streak white and shining. Colour snow-white, greyish, or yellowish-white, and pale-yellow. Adheres slightly to the tongue. B.B. and with acids acts like pure carbonate of magnesia, or the Breunnerite. With cobalt solution becomes red. Chem. com. pure carbonate of magnesia, with no mixture of metallic oxides. In that from Arendal, in which serpentine crystals occur, formerly considered bitter-spar, Scheerer finds no lime, and only 0·87 — 1·12 per cent. protoxide of iron. That from Baumgarten, in Silesia, contained 48·36 magnesia, 50·22 carbonic acid, 0·21 peroxide of manganese, and 1·39 water, according to Stromeyer; and in that from Salem, in India, he found 47·89 magnesia, 51·83 carbonic acid, and 0·28 lime. Brunner found in a very pure magnesite from Greece 51·03 magnesia, and 49·49 carbonic acid, with mere traces of alumina and iron peroxide. In the magnesite from Frankenstein, Silesia, Rammelsberg found 47·786 — 48·004 per cent. magnesia, and 52·214 — 51·995 of carbonic acid; but mixed with 3 — 8 per cent. silica. The magnesite of Castellamonte and Baldissero near Turin, and of Campo in Elba, containing according to Berthier 9 — 43 per cent. silica, and 1 — 12 per cent. water, seem a mixture of magnesite and opal. It is also found at Hurbschitz in Moravia, Valecas in Spain, and the Bare hills near Baltimore in North America.

203. MESITINE-SPAR, *Breithaupt, Dana, Dufrénoy.*

Rhombohedric, R 107° 14′; only occurs crystallized, in beautiful light-yellow or yellowish-grey, very splendent lenticular crystals, of the combination $-\frac{1}{2}R.0R$. Cleavage, along R perfect; H. = 3·5 — 4; G. = 3·35 — 3·4. Transparent or translucent. B.B., and with acids, acts like magnesite. Chem. com. $2\dot{M}g\,\ddot{C} + \dot{F}e\,\ddot{C}$. Analyses.

	Iron prot.	Magnesia.	Lime.	Carbon. acid.	Total.	
1	24·18	28·12	1·30	45·78	99·36	Fritzsche, Traversella (G. = 3·35).
2	26·61	27·12	0·22	46·05	100	Gibbs, Do.
3	33·92	21·72	...	43·62	99·26	Fritzsche (Pistomesite).

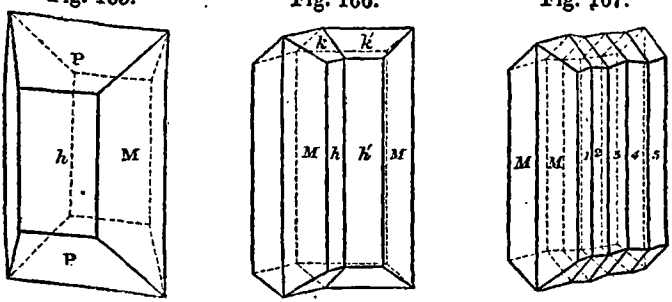
The only certain locality of this species is Traversella in Piemont, in druses of transparent quartz with dolomite; but it is also said to occur in Switzerland. No. 3, the Pistomesite of Breithaupt from Thurnberg near Flachau in Salzburg (sp. grav. = 4·41) contains one atom of each of the carbonates.

204. ARRAGONITE, *Phillips, Hauy;* Needle spar, Flos-ferri, Eisenbluthe, Arrogan, *Werner;* Prismatic Lime-Haloid, *Mohs.*

Rhombic; ∞P 116° 16′, $\breve{P}\infty$ 108° 27′; other very common forms

are $\infty\breve{P}\infty$, P, 0P, $6\breve{P}\frac{3}{4}$, and several brachydomes. The most common combinations are $\infty\breve{P}\infty$. (separate crystals in fig. 166) ∞P (*M*). $\breve{P}\infty$ (*k*), generally long prismatic; $\infty\breve{P}\infty . \infty$P . 0P, generally short prismatic; $6\breve{P}\frac{3}{4} . \infty$P . $\breve{P}\infty$, acute pyramidal. Also like fig. 165, in

Fig. 165. Fig. 166. Fig. 167.



which *P* is $\breve{P}\infty$; but simple crystals are rare from the great tendency to form macles, conjoined by a face of ∞P, and repeated with the planes of combination either parallel or inclined (figs. 166, 167). It occurs in crystals either imbedded singly, or united in druses; also in columnar and fibrous aggregates, and in crusts, stalactites, and other forms. Cleavage, brachydiagonal distinct, also prismatic along ∞P, and brachydomatic along $\breve{P}\infty$ imperfect. Fracture conchoidal or uneven; H.=3·5—4; G = 2·9 — 3 (2·931 transparent crystals from Bohemia, massive varieties as low as 2·7). Transparent or translucent; lustre vitreous; colourless, but often coloured yellowish-white to wine-yellow, reddish-white to brick-red, also light-green, violet-blue, or grey. In the closed tube, before reaching a red heat, it swells and falls down into a white coarse powder, evolving a little water. A portion of this powder heated in the forceps, B. B., colours the flame carmine-red when strontia is present; on charcoal it becomes caustic, and with fluxes acts like calc-spar. Chem. com. carbonate of lime $\dot{C}a\ \dot{C}$, occasionally mixed with carbonate of strontia. Analyses.

	Carb. of Lime.	Carb. of Strontia	Water.	Iron perox.	Total.	
1	97·10	2·46	0·41	...	99·97	Stromeyer, Kaiserstuhl (radiated).
2.	97·98	1·09	0·26	...	99·33	Do. Nertschinsk (columnar).
3	96·16	2·24	0·31	0·22*a*	98·75	Do. Eschwege (Do.)
4	98·06	1·01	0·21	0·14*a*	99·37	Do. Aussig (fibrous).
5	98·95	0·50	0·20	0·14*a*	99·79	Do. Waltsch (Do.)
6	98·62	0·99	0·17	0·11	99·89	Nentwich, Herrengrund (G.=2·93).
7	99·31	0·06	0·33	...*b*,	99·89	Do. Retzbanya (G.=2·86).

(*a*) Hydrated; (*b*) + 0·19 carbonate of copper.

Kirwan first suspected the presence of strontia in this mineral, and Stromeyer found it in all the varieties he examined, and hence thought it the cause of the physical and geometrical differences between arragonite and calc-spar. But Bucholz and Meissner discovered no strontia in arragonite from Neumark, Saalfield, Minden, Bastenne, and Limburg; and Delesse also, none in that from Herrengrund. Repeated experiments have shown that carbonate of lime with no strontia, in certain circumstances, assumes the form of arragonite, in others of calc-spar. G. Rose has observed that a salt of lime, precipitated by an alkaline carbonate in the cold, appears under the microscope rhombohedric like calc-spar; precipitated at a boiling heat, prismatic like arragonite. Mitscherlich had previously remarked the partial conversion of arragonite crystals into calcareous spar from volcanic action. Breithaupt has also observed, in a mine at Stenn near Zwickau, which had lain forty years under water, a deposit of calc-sinter, formed of alternate layers of calc-spar and arragonite, in one mass repeated thirteen times. After heavy rains or snow much water passed through the mine, and the alternate deposition probably arose from the different temperature during summer and winter floods.

This mineral never occurs forming rocks or entering into them as an essential constituent. It was first found in large macled crystals in gypsum at Molina and Valencia in Arragon in Spain. It is very common in amygdaloidal cavities and fissures in basalt and basaltic tufas, as at Bilin, Waltsch, and other parts of Bohemia; and in mineral veins or beds as at Leogang in Salzburg, Herrengrund in Hungary, and other places. The *flos ferri* or coralloid variety is common in the iron mines of Styria, and also in some limestone beds. The *Satin spar*, or fine fibrous silky variety, occurs at Dufton; in stalactitic masses in Galloway, Buckinghamshire, and Devonshire; and of beautiful snowy whiteness at Leadhills in Lanarkshire. It is also found in serpentine in Piemont, and in lava on Vesuvius, and in Iceland; and is deposited as tufa by the Carlsbad and other hot springs.

Arragonite is most readily distinguished from calc-spar by falling to pieces at a low temperature, which does not affect the latter, and also by its prismatic cleavage.

The *Tarnowitzite*, from Tarnowitz in Upper Silesia, contains carbonate of lead, in such abundance as to be shown by the blowpipe, proving its isomorphism with the carbonate of lime. Böttger found in it 95·94 carbonate of lime, 3·86 carbonate of lead, and 0·16 water (= 99·97). Kersten only 2·19 per cent. carbonate of lead.

II. Family.—Fluor Spar.

205. Fluor Spar, *Phillips;* Octahedral Fluor, *Jameson;* Fluate of Lime, *Phillips;* Fluss, *Werner;* Flusspath; Chaux Fluatée, *Hauy;* Octahedral Fluor-Haloid, *Mohs.*

Tesseral; the most common form is the cube $\infty O\infty$, then the octahedron O, and the rhombic dodecahedron ∞O (see figs. 1, 2, 3, p. 8). Many other forms occur in combinations, particularly various tetrakishexahedrons ∞On; the ikositetrahedrons 2O2 and 3O3; and several hexakisoctahedrons, especially 4O2 (figs. 4, 6, 7, above). The crystals, often large and very regularly formed, are attached singly or collected in druses. Macles are common. Also found in coarse granular or columnar masses, or compact and earthy. Cleavage octahedral perfect; and hence the conchoidal fracture is rarely perceptible. Brittle; H. = 4; G. = 3·1 — 3·2. Pellucid in all degrees; lustre vitreous; colourless, but generally coloured of very various, and beautiful shades of yellow, green, blue, and red; the more common being violet-blue, wine or honey-yellow, and leek or emerald-green; often two or more colours in one specimen. Many varieties phosphoresce when heated.

B.B. decrepitates, often violently, phosphoresces and fuses in thin splinters to an opaque mass; which, according to v. Kobell, in a stronger heat becomes infusible and alkaline, and colours the flame red, almost like strontia. Easily fusible with borax, salt of phosphorus, or *a little* soda. With gypsum or heavy spar forms a transparent bead, becoming opaque when cold. Slowly soluble in hydrochloric or nitric acids; readily in sulphuric acid with evolution of hydrofluoric acid. Chem. com. Ca F, or neutral fluoride of calcium, containing 48·14 fluorine, and 51·86 calcium (= 72·45 lime). In a compact grey variety from Gersdorf, Saxony, Klaproth found 67·75 (corrected 69·37) per cent. lime; Davy, in a specimen from Derbyshire, 72·683 per cent.; and Berzelius in that from Alston Moor 72·137, in that from Norberg, Sweden, 71·77 per cent. lime. In the Derbyshire variety Berzelius also found 0·5 per cent. phosphate of lime; and Kersten affirms that several blue varieties from Marienberg and Freiberg contain minute quantities of hydrochloric acid. Schaffhäutl finds in the violet-blue fluor spar from Welserdorf in the Upper Palatinate, 0·02073 per cent. nitrogen, 0·00584 hydrogen, 0·0365 carbon, and 0·08692 chlorous acid (!!). *Rammelsberg.*

Fluor spar occurs chiefly in veins, very rarely in beds as with magnetic iron or other ores, and never as a constituent of mountain rocks. It is a very common mineral in some countries, as in England, Saxony, and parts of the Harz; in other countries it is very

rare, as in Scotland, Ireland, Hungary, and Siebenburg. The lead mines of Alston Moor and Derbyshire furnish fine blue and green crystals, generally cubes, sometimes six or seven inches in the side. Octahedrons occur at Beeralston in Devonshire, and very many other forms in Cornwall. Octahedrons of an apple-green colour, are also found at Moldawa in the Bannat; of rose-red near Mont Blanc, and of emerald-green in North America. In Saxony cubes are more common of violet-blue, or wine-yellow colours; and the same form, sometimes above a foot in dimensions, has been found in primitive limestone in Jefferson County, New York, where it is usually green. Dark-blue cubes occur in greenstone near Gourock in Scotland, and fluor spar has also been found in granite at Monaltrie in Aberdeenshire, on the Avon in Banffshire, and in Sutherland. Compact varieties are common in Sweden, Cornwall, and near Stolberg in the Harz, forming large veins. Near Castleton in Derbyshire it occurs in large crystalline masses either with concentric colours or of a rich translucent blue (*Blue John*), and is wrought into various ornamental articles. Fluor spar is also used for etching on glass, for which it was first employed by Henry Schwanhard of Nurnberg in 1670; and more extensively as a flux in reducing metallic ores, especially iron and copper. Its name is derived from the latter employment.

The *Chlorophane* is a variety exhibiting a bright green phosphorescent light when heated, and is found chiefly near Nertschinsk in Siberia, and also at Alston Moor in England.

206. YTTROCERITE, *Berzelius*, *Phillips*, *Beudant*; Yttria Fluatée, *Dufrénoy*; Pyramidal Cerium Baryte, *Mohs*.

Very similar to fluor spar. Occurs in granular, crystalline masses, or in crusts. Cleavage, imperfect parallel to a tetragonal prism; H. = 4 — 5; G. = 3·4 — 3·5. Translucent or opaque; weak vitreous lustre; violet-blue to grey or white. B.B. the variety from Finbo yields water in the closed tube; the dark ones become white when heated. Infusible on charcoal alone, but with gypsum forms an opaque bead. That from Broddbo becomes first milk-white, then brick-red, but does not melt with gypsum; in other respects acts like the Fluocerite. Soluble in hydrochloric acid, and evolve fluorine when heated with sulphuric acid. Analyses.

	Lime.	Cerium perox.	Yttria	Hydro-fluoric acid.	Alu-mina.	Silica.	Total.	
1	47·63	18·22	9·11	25·05	...	...	100	Gahn and Berzelius, Finbo.
2	50·00	16·45	8·10	25·45	...	...	100	Do. Do.
3	34·7	13·3*a*	15·5	19·4*b*	6·5*c*	10·6*d*	100	Jackson, Massachusetts.

(*a*) With lanthanium; (*b*) fluorine; (*c*) with iron peroxide; (*d*) and silicate of cerium.

Nos. 1 and 2 are the extremes of several analyses, and show it to consist of neutral fluorides of calcium, cerium, and yttrium, mixed according to Berzelius in variable proportions. It was first found at Finbo and Broddbo near Fahlun, and lately in Massachusetts, and at Amity in New York. Berzelius and Rammelsberg assert that No. 3 can have been at best but a mere qualitative examination—since 19·4 fluorine implies a surplus of 8·25 per cent.; but Alger gives it as fluoric acid.

207. FLUOCERITE, *Haidinger;* Neutral fluate of Cerium, *Phillips, Mohs;* Fluocerine, *Dana;* Cerium Fluaté, *Dufrénoy.*

Hexagonal, ∞P . 0P, in layers or massive; fracture uneven; splintery; H. = 4 — 5; G. = 4·7. Opaque or translucent on the edges; lustre weak; colour pale brick-red or yellowish; streak yellowish-white. In the closed tube, with a strong heat, gives out fluoric acid, and becomes white; in the open tube the same, but becomes dark-yellow. B.B. infusible on charcoal; with fluxes, acts like pure oxide of cerium. Chem. com., according to Berzelius, Ce F + $Ce^2 F^3$, or a mere mixture of these compounds. In the variety from Broddbo he found 82·64 peroxide of cerium, 1·12 yttria, and 16·24 hydrofluoric acid (= 100). Found at Finbo and Broddbo near Fahlun, imbedded in greyish albite, or more rarely in quartz.

208. FLUOCERINE, *Hausmann;* Subfluate of Cerium, *Phillips;* Basic fluate of Cerium, *Berzelius, Mohs;* Cerium Hydrofluaté, *Dufrénoy.*

Occurs in crystalline masses, with traces of cleavage in several directions. Fracture conchoidal; H. = 4·5. Opaque; lustre vitreous or resinous; colour yellow, inclining to red or brown; streak brownish-yellow. B.B. when heated on charcoal becomes black, and on cooling first brown, then red, and finally dark-yellow, but is infusible. In that from Finbo Berzelius found 84·20 peroxide of cerium, 10·85 hydrofluoric acid, and 4·95 water (= 100), or $Ce^2 F^3$ + $\ddot{C}\ddot{e}\ \dot{H}$. In a similar mineral from Bastnaes mine near Riddarhytta, Hisinger found fluoride of cerium (and lanthanium) 50·15, peroxide of cerium (and lanthanium) 36·43, and water 13·413, or $Ce^2 F^3$ + $\ddot{C}\ddot{e}\ \dot{H}^4$, consequently the simple basic salt. A mixture of fluocerite and fluor-yttrium, also containing silica, is found at Finbo.

209. CRYOLITE, *D'Andrada, Phillips;* Kryolith, *Naumann;* Alumine fluatée alcaline, *Hauy;* Axotomous Orthoclase-Haloid, *Mohs.*

Rhombic (or tetragonal ?), but as yet only in indistinct crystalline or

coarse granular masses; Cleavage, basal perfect, macrodiagonal and brachydiagonal less so, the three planes being nearly at right angles; brittle; H.= 2·5 — 3; G. = 2·9 — 3. Translucent, and after immersion in water almost transparent; lustre vitreous, but on 0P rather pearly; colourless and snow-white, but often greyish, yellowish, or reddish. B.B. fuses very easily (even in the flame of a candle) to a white enamel. In open tube shows traces of fluorine. Partially soluble in hydrochloric acid; wholly so in sulphuric, with evolution of fluorine. Chem. com. 3 Na F + Al^2 F^3, or 53·6 fluorine, 13 aluminium, and 33·4 sodium. Analyses.

	Alumina.	Soda.	Fluoric acid.	Aluminium.	Sodium.	Fluor.	Total.	
1	24	36	40	...	...	...	100	Klaproth.
2	24·40	44·25	—	13·00	32·93	54·07	100	Berzelius.
3	24·83	43·89	... *a*	...	...	...	...	Chodnew.

(*a*) + 0·83 magnesia and manganese.

Occurs only at Arksutfiord in West Greenland, in gneiss in two small veins, the one containing the white variety only; the other the coloured variety, with galena, iron pyrites, carbonate of iron, quartz, and felspar. The specimens are sometimes six inches in diameter.

210. Chiolite, *Hermann.*

Rhombic; massive, and distinctly crystalline or granular. Cleavage, ∞P 114° rather perfect. H. = 4; G. = 2·72, *Hermann.* Lustre resinous; colour white. B.B. easily fusible, colouring the flame deep yellow; evolves fluoric acid in the open tube, and with sulphuric acid. Melts in a platina capsule over the lamp, which cryolite does not. Analyses.

	Aluminium.	Sodium.	Potassium.	Fluorine.	Magnesium.	Yttrium	Loss.	Total.	
1	18·69	23·78	...	57·53	...	...	...	100	Hermann.
2	16·43	26·54	0·59	53·61	0·93	1·04 ?	0·86	100	Chodnew.
3	16·54	26·85	...	...	...	...	...	...	Do.

Hermann, from his analysis, gives the formula 3 Na F + 2 Al^2 F^3; and Chodnew, from his, 2 Na F + Al^2 F^3. Rammelsberg has recently examined this mineral, and finds there are two compounds, only differing in specific gravity. One, like Hermann's variety, with G.= 2·842 — 2·898 in powder, contains in 100 parts, according to three trials of Pearce in R.'s laboratory:—

	(1)	(2)	(3)
Sodium,.....	24·69 ...	24·56 ...	22·91
Aluminium, ...	18·02 ...	17·72 ...	19·59

The other, like Chodnew's, gave on four trials, G. = 3·003, 3·006, 3·077, 3·077, and contained, according to R.,

	(1)	(2)	(3)
Sodium, ...	27·53	... 28·29	... 27·22
Aluminium, ...	...	... 15·40	... 16·11

It occurs at Miask in Siberia.

The *Fluellite* of Wollaston, found with wavellite and uranite on quartz at Stenna-gwyn in Cornwall, is very rare, only three or four specimens being known. It occurs in small, white, transparent, rhombic pyramids, and, according to Wollaston, consists essentially of fluorine and aluminium.

211. HOPEITE, *Brewster;* Prismatic Monoclase-Haloid, *Mohs.*

Rhombic; $\infty\breve{P}2 = 81° 34'$, $P\infty = 101° 24'$. Crystals generally prismatic. Cleavage, macrodiagonal perfect; brachydiagonal less so. H. = 2·5 — 3; G. = 2·76. Lustre vitreous or pearly. Colour greyish-white. B.B. gives off water, and melts easily to a clear globule, tinging the flame green. Soluble in acids without effervescence. Chem. com., according to Nordenskiöld, oxide of zinc and cadmium, with an earth, an acid not volatile by heat (the phosphoric or boracic), and much water. Occurs in the calamine mines of Altenberg near Aix la Chapelle, and named after Dr Hope, Professor of Chemistry in Edinburgh.

212. APATITE, *Werner, Phillips;* Phosphate of Lime; Chaux Phosphatée, *Hauy;* Rhombohedral Fluor-Haloid, *Mohs.*

Hexagonal, and pyramidal-hemihedric (see p. 23); P 80° — 81°, the most common forms are, ∞P, $\infty P2$, $0P$, P, $\frac{1}{2}P$, $2P$, and $2P2$; the rarer, dihexagonal pyramids and prisms, of which only half the faces are seen. The crystals (figs. 168, 169) are generally short prismatic

Fig. 168.

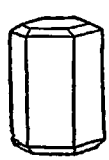
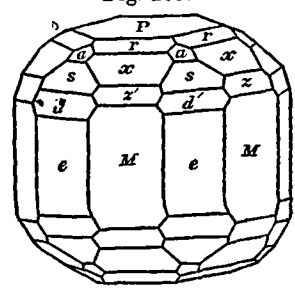


Fig. 169.



or thick tabular, and the prisms often striated vertically. They are

either singly attached, or imbedded, or united in druses. It also occurs disseminated in round grains; or massive with a distinct, granular structure; and in fibrous or compact masses. Cleavage, prismatic along ∞P and basal, both imperfect. Fracture conchoidal, or uneven and splintery. Brittle. H. = 5; G. = 3·16 — 3·22. Transparent to opaque; lustre vitreous on the crystal-faces, resinous on the cleavage planes and fracture. Colourless, and sometimes white, but generally green, grey, blue, violet, or red in light shades, and sometimes varying in the same crystal. B.B. fusible in thin splinters with much difficulty to a colourless, translucent glass. With borax slowly fusible to a clear glass. In salt of phosphorus soluble to a large amount, forming a clear glass, which, when nearly saturated, becomes opaque on cooling, and presents crystalline faces. Difficultly soluble in boracic acid, yielding with iron wire phosphate of iron. Moistened with sulphuric acid it colours the flame green. With salt of phosphorus and copper oxide shows traces of chlorine; heated with the former in an open tube, or treated with sulphuric acid, reaction for fluoric acid. Soluble in nitric or hydrochloric acid. Chem. com. $(3\,\dot{C}a^3\ddot{P} + Ca\,(Cl, F)$ or phosphate of lime, with chloride and fluoride of calcium, either singly (the chlorine and fluorine apatites) or mixed in uncertain proportions. Analyses.

	Lime.	Hydroch. acid.	Phos. and fluor.-acids with loss.	Total.	
1	54·75	2·10	42·90*a*	100	G. Rose, Snarum, Norway, G. = 3·174.
2	55·30	0·43	44·27	100	Do. Cabo de Gata, Spain, G. = 3·235.
3	55·89	0·39	43·72	100	Do. Arendal, G. = 3·22, grass-green.
4	55·58	0·07	44·35	100	Do. Greiner, Tyrol, G. = 3·175.
5	55·87	0·05	44·08	100	Do. Faltigl, Do. G. = 3·166.
6	55·66	0·02	44·32	100	Do. St Gotthardt, G. = 3·197.
7	55·31	0·07*b*	...	...	Rammelsberg, Schwarzenstein, Zillerthal.

(*a*) + 0·25 peroxide of iron and manganese; (*b*) chlorine.

Nos. 1 and 4 were massive, the others crystallized. In No. 7, Rammelsberg estimated the composition from the formula as 49·66 lime, 42·58 phosphoric acid, 4·06 calcium, 0·07 chlorine, and 3·63 fluorine; but the fluorine determined by Wohler's method was in three experiments only 0·61, 0·52, and 0·93 per cent., or at most a fourth of that required by the theory. Hence, either the method or the formula is defective.

Apatite is best known as occurring in mines of tin and iron, as at Ehrenfriedersdorf in Saxony, Zinnwald, and Schlackenwald in Bohemia, in Cornwall, at Caldbeck Fell in Cumberland, and in Devonshire. It also occurs in veins with quartz, felspar, and mica, and with turmaline and hornblende in mica slate. Apatite is disseminated in many

of the igneous and older crystalline rocks, as in granite, in the zircon-syenite of southern Norway at Frederiksvärn, and in capillary crystals in the volcanic formations of Albano with hauyne and mica, and in the basalt of Capo di Bove with augite and nepheline. Fine crystals have been found in America, at Hammond, where one crystal was 12 inches long and weighed 18 lbs., and Edenville in New York, in Long Island in Maine, and Norwich in Massachusetts. An opaque greenish-blue variety from Arendal is named *Moroxite;* and the translucent wine-yellow crystals from the Zillerthal in Tyrol, where it is imbedded in green talc, *asparagus-stone* or *spargelstein.* The massive variety or *phosphorite*, which forms a vein in clay-slate at Logrosan in Estremadura in Spain, has been recently analyzed by Dr Daubeny, who found 81·15 phosphate of lime, 14·00 fluoride of calcium, 3·15 peroxide of iron, and 1·70 silica (= 100), with 0·2 per cent. chlorine. It therefore contains more fluorine than the crystallized varieties, and leads to the formula 3 Ca (F, Cl) + 4 $\dot{Ca}^3 \ddot{P}$.

From the mineral dispersed in rocks and partially soluble in water, it is probable that the phosphate of lime contained in plants and animals is in great measure derived. Phosphate of lime has recently been found in great abundance in the green-sand and other newer secondary rocks of England, and enters in smaller proportion into the composition of most limestones.

Talk-apatite, or *Magnesia-apatite* of Hermann, from Kusiusk in the Schischimscha mountains in the Ural, occurs in long prismatic, hexagonal crystals. H. = 5; G. = 2·7 — 2·75. Milk-white on the fresh fracture, but on the surface yellowish, dull and earthy. He found in it 7·74 magnesia, 37·50 lime, 39·02 phosphoric acid, 0·91 chlorine, 2·10 sulphuric acid, 1·00 peroxide of iron, 2·23 fluorine and loss, and 9·50 insoluble in nitric acid (= 100). It is probably a partially decomposed apatite, with the lime in part replaced by magnesia. The Pseudo-Apatite from the Kurprinz mine at Freiberg seems also an impure or earthy variety.

213. HERDERITE, *Haidinger;* Allogonit, *Breithaupt;* Prismatic-Fluor-Haloid, *Mohs.*

Rhombic, P middle edge 77° 20′, $\frac{3}{2}\breve{P}\infty$, middle edge 65°, ∞P 115° 53′. The crystals consist essentially of these forms with 0P, and appear thick tabular, almost hexagonal. Cleavage, basal and prismatic along ∞P, both imperfect; fracture conchoidal. H. = 5; G. = 2·9 — 3. Translucent; lustre vitreous, inclining to resinous; colour yellowish or greenish-white. B.B. difficultly fusible to a white enamel; moistened with sulphuric acid colours the flame green; and becomes blue with cobalt solution. Soluble in warm hydrochloric

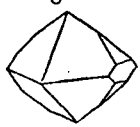
acid. Chem. com. according to Turner and Plattner, phosphate of alumina and phosphate of lime with fluorine.

Occurs imbedded in fluor spar at the tin mines of Ehrenfriedersdorf in Saxony, but is extremely rare.

214. Childrenite, *Brooke.*

Rhombic, P 102° 30′, 130° 20′, 97° 50′; usual form P . $2\breve{P}\infty$. $\infty\breve{P}\infty$, with P greatly predominating (fig. 170). Cleavage, pyramidal along P imperfect. H = 4·5 — 5. Translucent; lustre vitreous; colour yellowish-white to wine or ochre-yellow. Chem. com. according to Wollaston, phosphoric acid, with alumina and peroxide of iron. It occurs in very minute crystals, either singly or forming crusts on carbonate of iron or quartz at Tavistock in Derbyshire, Crinnis in Cornwall, and in larger and more distinct crystals at Callington in Cumberland.

Fig. 170.



215. Xenotime, *Beudant;* Phosphate of Yttria, Pyramidal Retin-Baryte, *Mohs.*

Tetragonal, P 82°; only the primitive form known in single imbedded crystals. Cleavage, prismatic along ∞P; H. = 4·5; G. = 4·39. Translucent in thin splinters; lustre resinous; colour yellowish or reddish-brown, and flesh-red. Streak yellowish-white or flesh-red. B.B. infusible; with bórax slowly to a transparent glass, which with a larger quantity becomes opaque on cooling. Very slowly dissolved in salt of phosphorus. With boracic acid and iron wire yields phosphate of iron. Chem. com. according to Berzelius, $\dot{Y}^3\,\ddot{P}$ with 62·82 yttria, and 37·18 phosphoric acid. His analysis gave 62·58 yttria, 33·49 phosphoric acid, with traces of fluoric acid, and 3·39 (basic) phosphate of iron. It is found at Lindesnaes in Norway, and Scheerer describes a similar mineral from Hitteroe near Flekkefiord, but gives its composition as $\dot{Y}^4\,\ddot{P}$, or 68 yttria, and 32 phosphoric acid.

216. Boracite, *Werner;* Borate of Magnesia. Tetrahedral Baracite, *Mohs.*

Tesseral, and hemihedric-semitesseral; the most common forms are $\infty O\infty$, ∞O, and $\frac{O}{2}$, and usually one of the first two predominating. The crystals are imbedded, perfectly formed, and small. Cleavage, octahedral, very imperfect. Fracture conchoidal, brittle. H. = 7; G. = 2·9 — 3. Transparent, or translucent only on the edges. Lustre vitreous or adamantine; colourless or white, often greyish, yellowish, or greenish. It becomes polar electric by heat,

the angles of the cube replaced by the bright faces of the tetrahedron, being the antilogue poles, those not replaced, or by rough faces, the analogue. B.B. fuses with difficulty to a bead, clear and yellowish when warm, but on cooling forms a white opaque mass of needle-like crystals. At same time it colours the flame green (v. Kobell); the colour being more distinct when it is fused with sulphate of potash and fluor spar. When fused with sulphate of potash alone, and dissolved in water, the magnesia may be precipitated by salt of phosphorus. Completely soluble in hydrochloric acid. Chem. com. $\dot{M}g^3\ \ddot{B}^4$, with 69·8 boracic acid, and 30·2 magnesia. Paff (1) and Stromeyer (2) analysed the boracite from Segeberg in Holstein, and Arfvedson (3) and Rammelsberg (4, 5) that from Lüneburg, with the following results:—

	(1)	(2)	(3)	(4)	(5)
Magnesia	36·3	33	30·3	30·748	31·124
Boracic acid	63·7	67	69·7	69·252	68·876

From the unusual character of the above formula, some have been inclined to regard boracite as a neutral salt, $\dot{M}g\ \ddot{B}$, which corresponds better with the first analysis. Berzelius has proposed $\dot{M}g\ \ddot{B}^2 + 2\dot{M}g\ \ddot{B}$, referring at the same time to its double electric axes, and the peculiar want of symmetry in the formation of the crystal-faces.

Sir D. Brewster finds in this mineral one axis of double refraction which passes through two angles of the cube. It thus forms a remarkable exception to the otherwise universal rule that minerals belonging to the tesseral system possess only single refraction, and hence he considered it as a cubic-rhombohedron. The researches of Biot, however, show that the phenomena of polarization exhibited by foliated minerals are often independent of their form of crystallization.

Boracite occurs in gypsum near Lüneberg and Segeberg in Holstein.

A compact boracite has recently been found at a depth of 800 feet in boring for salt at Stassfurth in Northern Germany. Karsten found in it 29·48 magnesia, 69·49 boracic acid, and 1·03 carbonate of iron protoxide, with traces of manganese and hydrated peroxide of iron (= 100). It is easily soluble in diluted acids; and has G. = 2·9134. It seems to form beds with rock-salt and gypsum.

The *Rhodizite* of G. Rose agrees almost perfectly in form and physical properties with boracite; only its H. = 8 and G. = 3·3 — 3·42. B.B. fuses difficultly on the edges, colouring the flame first green, then green above and red below, and at last in some varieties all red. Difficultly soluble in hydrochloric acid. Not analyzed, but seems a

boracite with the magnesia replaced by lime, and was found in small translucent and highly splendent crystals, $\infty O . \frac{O}{2}$, on red tourmaline and quarz, at Sarapulsk and Schaitansk near Mursinsk in Siberia.

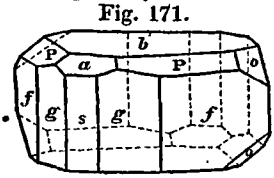
217. Hydroboracite, *Hess.*

Crystalline, but form unknown. In radiating foliated masses, like gypsum. H. = 2; G. = 1·9 — 2. Translucent; white, but partly coloured red by peroxide of iron. In closed tube yields water. B.B. melts easily to a clear, colourless glass, tinging the flame green. Easily soluble in warm hydrochloric or nitric acids. Chem. com. $\dot{C}a^2\ \dddot{B}^3 + \dot{M}g^2\ \dddot{B}^3 + 12\ \dot{H}$, very nearly agreeing with the mean of two analyses by Hess, = 13·52 lime, 10·57 magnesia, 49·58 boracic acid, and 26·33 water (= 100). Hess found the specimen in a collection of Caucasian minerals, but the locality where it occurs is unknown.

218. Datholite, *Werner, Phillips;* Borate of Lime, Chaux boratée siliceuse, *Hauy;* Prismatic Dystome-spar, *Mohs.*

Monoclinohedric, C = 88° 19′, ∞P (*f*) 77° 30′, ∞P2 (*g*) 116° 9′, —P (*P*) 122°, —2P∞ (*a*) 43° 56′, (∞P∞) (*s*), (2P∞) (*o*). The crystals exhibit numerous combinations, often very complex, but are usually short prismatic, or thick tabular (fig. 171), from predominance of the prisms just mentioned, and the basal pinacoids (*b*). They are generally combined in druses. It also forms coarse granular masses. Cleavage, orthodiagonal and prismatic along ∞P, very imperfect; fracture uneven or conchoidal; H. = 5 — 5·5; G. = 2·9 — 3. Transparent or translucent; lustre vitreous, on the fracture resinous; colourless or white, inclining to grey, green, yellow, and red. In closed tube yields water. B.B. intumesces, and melts easily to a clear glass, colouring the flame green; easily fusible in borax; the powder gelatinizes in hydrochloric acid; the evaporated solution mixed with alcohol burns with a green flame. Chem. com. perhaps $\dot{C}a^2\ \dot{S}i + \dddot{B}\ \dot{S}i + \dot{H}$ = 38·3 silica, 21·5 boracic acid, 34·6 lime, and 5·6 water; the boracic acid is considered as acting as a base, but Berzelius prefers regarding it as an acid, when the formula becomes $\dot{C}a\ \dddot{B} + \dot{C}a\ \dot{S}i + \dot{H}$. Analyses, next page.

Fig. 171.



At Arendal massive datholite forms veins in the hornblende rock and gneiss near the magnetic iron, and contains druses of the crystallized variety alone, or with calc-spar. It also occurs on Utoe in Södermanland; and at Andreasberg in the veins of silver ore. In Scotland

	Silica.	Boracic acid.	Lime.	Watr.	Total.	
1	36·5	24·0	35·5	4·0	100·00	Klaproth, Arendal.
2	37·65	21·24	35·40	5·70	100·00	Rammelsberg, Do.
3	37·52	21·38	35·40	5·70	100·00	Do. Do.
4	37·36	21·26	35·67	5·71	100·00	Stromeyer, Andreasberg.
5	38·51	21·34	35·59	4·60	100·04	Du Menil, Do.
6	38·48	20 31	35·64	5·57	100·00	Rammelsberg, Do.
7	36·19	19·34	35·22	8·64	99·28	Do. Arendal (Botryolite).
8	36·39	18·34	34·27	10·23*a*	100·00	Do. Do. Do.

(*a*) from loss + 0·77 alumina and peroxide of iron.

it is found in the trap rocks of Salisbury Craigs, and in Glen Farg in Perthshire. Fine crystals occur in amygdaloids in Connecticut and New Jersey in North America. Lévy named some complex crystals Humboldtite. They are found at Sonthofen in Bavaria, in veins of calc-spar in sandstone; and on the Seisser Alpe, and at Theiss near Clausen in the Tyrol, in agate nodules with prehnite and zeolites. It has also been met with in the ejected blocks on Vesuvius.

The *Botryolite* of Hausmann (Nos. 7, 8) seems almost a variety of datholite. It occurs massive or fine fibrous, forming small botryoidal or reniform crusts of a snow-white or hair-brown colour, investing calc-spar crystals. It agrees in physical and chemical characters with datholite, and has the same composition, but with two atoms water. It has only been found at Arendal in the magnetic iron ore with calc-spar, quartz, schorl, and pyrites.

III. Family.—Heavy Spar.

219. Barytes; Heavy spar, Sulphate of Barytes, *Phillips, &c.*; Schwerspath, Baryt, Schwefelsaurer Baryt, *Werner, &c.*; Baryte sulfatée, *Hauy*; Prismatic Hal-Baryt, *Mohs.*

Rhombic, ∞P (*g*) 101° 40′, $\breve{P}\infty$ (*f*) 74° 35′, $\frac{1}{4}\bar{P}\infty$ (*d*) 102° 17′; these three forms, with 0P (*c*), predominate in most of the very numerous combinations (figs. 172, 173, 174). The character of the crystals is either tabular from the predominance of 0P, or columnar from prismatic forms, usually the domes $\breve{P}\infty$, or $\frac{1}{4}\bar{P}\infty$, and hence the prisms are generally to be placed horizontally. The crystals occur either singly, or more often united in druses or groups. It also occurs in foliated, columnar, fibrous, granular or compact masses. Cleavage, basal perfect, prismatic along ∞P rather less perfect, brachydiagonal in traces only. H. = 3 — 3·5; G. = 4·3 — 4·7. Transparent to

translucent; lustre vitreous or resinous; colourless and white, but generally coloured reddish-white, or flesh-red, yellow, grey, bluish,

Fig. 172.

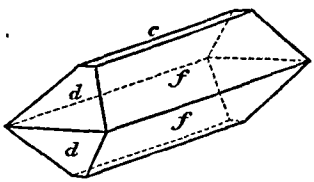


Fig. 173.

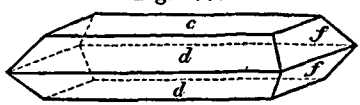
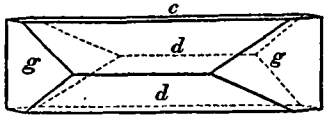


Fig. 174.



greenish, or brown. B.B. decrepitates violently, and fuses very difficultly, or only on the edges, at the same time colouring the flame yellowish-green. In the reducing flame it forms sulphuret of barium, which, when dissolved in hydrochloric acid, evaporated, and mixed with alcohol, does *not* cause it to burn with a red colour. Not soluble in acids. Chem com. $Ba\dot{S}$ with 34·3 sulphuric acid, and 65·7 baryta. Analyses.

	Sulph. of baryta.	Sulph. of strontia.	Silica.	Watr.	Iron.	Total.	
1	97·50	0·85	0·8	0·7	...	99·35	Klaproth, Frieberg (foliated).
2	90	...	10	...	...	100	Do. Peggau, Styria (granular).
3	99	...	...	...	trace.	99	Do. New Leiningen (fibrous).
4	99·38	...	...	0·07 *a*	0·05*b*	99·50	Stromeyer, Nutfield, Surrey.
5	86 00	6·75	5·75	0·37	...	98·87	Jordan, Klausthal (compact).
6	99·4	0·6*c*	...	...	...	100	Rammelsberg, Silbach.
7	83·48	15·12	0 89*d*	0·25*c*	...	99·74	Do. Görzing, Anhalt-Köthen.

(*a*) With colouring matter; (*b*) hydrated peroxide; (*c*) sulphate of baryta, with traces of strontia; (*d*) lime; (*e*) earthy matter.

No. 6 was a colourless crystal, with G. = 4·4864; No. 7 a brownish-yellow crystal from a pit of brown coal, with G. = 4·488. In a specimen from Nutfield (No. 4), Stromeyer formely found 33·87 sulphate of baryta, and 65·81 sulphate of strontia.

This is a very common mineral in rocks of all ages, though never forming one of their essential constituents. It occurs chiefly in veins, either alone as in porphyry, or accompanying ores. Its crystal forms are very numerous, Hauy describing 73, and Lévy 42 combinations. Tabular crystals of a large size are found at Dufton, one weighing 42 lbs.; smaller ones in Bohemia, and of splendid colours at Felsobanya and Kremnitz in Hungary. Prismatic forms are common in Auvergne. Fine varieties also occur in many parts of the United

States. Columnar heavy-spar, the *Stangenspath* of Werner, in indistinct prismatic pearly crystals, is very common at Freiberg. The *Bolognese stone* is a radiated variety from near Bologna, which, after being heated and placed in the sun's rays, phosphoresces in the dark. The *Cawk* from Derbyshire and Staffordshire is a massive variety. Veins of this mineral are common in the felspar rocks of Scotland, as in the Braid Hills near Edinburgh, the Pentlands, and Cheviots. It is used as a white pigment, alone or with white-lead, and mined for this purpose in the granite of Arran. When mixed with ores it is considered prejudicial; and it is also a violent poison.

The *Lime barytes* from Freiberg, Strontian, and Derbyshire, seems merely a mixture of this mineral with sulphate of lime. Its crystals, chiefly tabular, and combined in rosettes and other groups, agree in form with barytes ($\infty P = 101° 53'$, Breit.). G. = 4·0 — 4·3.

The *Hepatite*, of a more or less dark-grey colour, from the Kongsberg mines in Norway, seems a mere mixture of barytes with carbonaceous matter. The *Allomorphite* of Breithaupt, found in scaly masses at Unterwirbach near Rudolstadt, agrees in essential characters and chemical composition (98·05 sulphate of baryta, 1·90 sulphate of lime, *Gerngross*) with barytes.

220. DREELITE, *Dufrénoy.*

Rhombohedric; R 93°. The crystals occur attached to sandstone. Cleavage, rhombohedric along R imperfect; H. = 3 — 4; G. = 3·2 — 3·4. Lustre, externally dull, on the cleavage faces pearly. Colour white. B.B. fuses to a white vesicular glass. Effervesces with hydrochloric acid, but only partially dissolves. Chem. com. $\dot{C}a\ \ddot{S} + 3\ \dot{B}a\ \ddot{S}$ according to Dufrénoy, who found on analysis, 61·73 sulphate of baryta, 14·27 sulphate of lime, 8·05 carbonate of lime, 9·71 silica, 2·40 alumina, 1·52 lime, 2·34 water (= 100). It was found in the old lead mine of Nuissière near Beaujeu in the Rhone department in France.

221. WITHERITE, *Werner, Phillips;* Carbonate of Barytes, Baryte carbonatée, *Hauy;* Diprismatic Hal-Baryt, *Mohs.*

Rhombic; ∞P 118° 30', $2\breve{P}\infty$ 68°. In general form the crystals appear hexagonal, and with the macles resemble those of arragonite, but are rather rare. Two of the more common combinations are $\infty P \cdot \infty\breve{P}\infty \cdot 2\breve{P}\infty$ (fig. 175), and this form with $\breve{P}$. It is more common in spherical, botryoidal, or reniform masses, with a drusy surface, and radiated, columnar texture. Cleavage, ∞P distinct, $2\breve{P}\infty$ and $\infty\breve{P}\infty$ imperfect. Fracture uneven; H. = 3 — 3·5; G. = 4·2 — 4·3. Semitransparent or translucent, but the crys-

Fig. 175.

tals often covered by a dull, opaque crust. Lustre vitreous, or resinous on the fractured surface. Colourless, but generally yellowish or greyish. B.B. fuses easily to a transparent globule, becoming opaque when cold. On charcoal after some time boils, becomes caustic, and sinks into the support. Soluble with effervescence in nitric or hydrochloric acids when not too much concentrated. Chem. com. $\dot{B}a\ \ddot{C}$, or 22·3 carbonic acid and 77·7 baryta; with which the analyses of Klaproth of a variety from Anglesark (22 carbonic acid, 78 baryta), and of Withering (21·4 carbonic acid, 78·6 baryta), closely agree. It is found abundantly in various parts of England, as in the lead mines of Alston Moor in Cumberland, in Northumberland, and in Lancashire, where it is used for poisoning rats; and in less amount at Peggau in Styria, Leogang in Salzburg, in Hungary, Sicily, Siberia, and Chili.

The sulphato-carbonate of barytes described by Thomson, from a single specimen found at Brownley hill in Cumberland, is probably an accidental mixture. It contained 64·8 carbonate of baryta, and 34·3 sulphate of baryta, and formed broad hexagonal prisms, ending in an obtuse six-sided pyramid.

222. ALSTONITE, *Breithaupt;* Baryto-calcite, *Johnston.*

Rhombic, ∞P 118°, $\breve{P}\infty$ 108°, usual combination $P . 2\breve{P}\infty . \infty P$, resembling a hexagonal pyramid. Cleavage, ∞P and $\infty\breve{P}\infty$ rather distinct. H. = 4 — 4·5; G. = 3·65 — 3·76. Translucent; weak resinous lustre; colourless or greyish-white. Chem. com., according to Johnston, $\dot{B}a\ \ddot{C} + \dot{C}a\ \ddot{C}$, with 66 carbonate of baryta and 34 carbonate of lime, thus identical with the Baryto-calcite. Delesse and Descloizeux confirm this statement, but find occasionally 1 per cent. carbonate of strontia. It is thus a distinct instance of dimorphism. Found at Fallowfield near Hexham in Northumberland, and at Alston-Moor in Cumberland.

223. BARYTO-CALCITE, *Brooke;* Hemiprismatic Hal-Baryt, *Mohs.*

Monoclinohedric, C = 69° 30′; ∞P 95° 15′, P 106° 54′, $P\infty$ 119°. Fig. 176. The crystals (fig. 176) composed of these and a few other forms are usually prismatic, small, and united in druses. It also occurs in columnar and granular masses. Cleavage, P perfect, $P\infty$ less perfect. H. = 4; G. = 3·6 — 3·7. Transparent or translucent; lustre vitreous, inclining to resinous; colour yellowish-white. B.B. infusible, but becomes opaque, and at length caustic. (In a strong heat becomes covered by a greenish glass, and colours the flame

a faint yellowish-green, *v. Kobell*). With borax effervesces and forms a transparent glass, coloured by manganese-peroxide, which becomes colourless in the reducing flame. Decomposed by soda, which, with the baryta, sinks into the charcoal, leaving the lime behind. Chem. com. identical with alstonite above. Found at Alston-Moor in Cumberland.

Thomson has given the same name to a mineral found between Leeds and Harrowgate in Yorkshire, in which he finds 71·9 sulphate of lime and 28·1 sulphate of baryta. Rammelsberg remarks that these numbers correspond to no simple formula, and rather indicate a mixture. The *Bicalcareo-carbonate of Barytes* of Thomson, from the north of England, is, according to Johnston, only the Baryto-calcite of Brooke. Thomson has subsequently found in it carbonate of manganese.

224. CELESTINE, *Jameson*, *Phillips*; Cölestin, *Werner*; Strontiane Sulfatée, *Hauy*; Prismatoidal Hal-baryt, *Mohs*.

Rhombic; forms like those of barytes and sulphate of lead; ∞P 104°, P̆∞ 75° 40′; usual combinations, P̆∞ . ∞P . 0P, this with ½P̆∞, also 0P . ∞P, and others. The crystals (fig. 177) are chiefly prismatic in the direction of the brachydiagonal, from predominance of P̆∞, or tabular from the basal pinacoid, and usually united in druses. It also occurs massive, columnar, and foliated; or fibrous, and in fine granular or compact, reniform masses. Cleavage, basal perfect; prismatic along ∞P less perfect. H. = 3 — 3·5; G. = 3·9 — 4. Transparent or translucent; lustre vitreous or resinous; colourless, but usually bluish-white to indigo-blue, and rarely reddish or yellowish. B.B. decrepitates and fuses easily to a milk-white globule. Colours the flame carmine-red (most distinctly when the assay heated in the reducing flame is moistened with hydrochloric acid, *v. Kobell*). On charcoal in the reducing flame forms sulphuret of strontium; which, dissolved in hydrochloric acid and evaporated, when mixed with alcohol, causes it to burn with a carmine-red flame. It is distinguished from barytes by a splinter after ignition in the inner flame being moistened with hydrochloric acid, and held in the blue border of the flame without blowing on it, colouring this of a lively purple-red, *v. Kobell*. Scarcely affected by acids. Chem. com. Sr S, with 43·6 sulphuric acid and 56·4 strontia. Analyses, next page.

Fig. 177.

Celestine is found in the greywacke rocks at Leogang in Salzburg, in the old red sandstone near Inverness in Scotland, and in the magnesian limestone at Knaresborough in Yorkshire; but is more com-

	Stron-tia.	Sulp. acid.	Iron perox.	Ba-ryta.	Carb. lime.	Silica.	Watr.	Total.	
1	58	42	trace	...	...	...	...	100	Klaproth, Frankstown, Pens.
2	56·27	42·95	0·03*a*	...*b*	0·10	...	0·11	99·59	Stromeyer, Dornburg, Jena.
3	55·18	42·74	0·04*c*	0·86	0·02*d*	..	0·05	99·20	Do. Suntel near Münden
4	97·60		0·65	0·97*f*	...	0·11	0·25	99·58	Do. Dehrself, Hanover.
5	56·35	43·08	0·03*c*	...	0·09	..	0 18	99·73	Do. Girgenti.
6	92·15		0 50	1·87*f*	1·83	1·00	...	97·35	Brandes, Fassa Valley.
7	54·73	43·76	...	...	1·42*e*	...	...	99·91	Madrell, Dornburg.
8	35·72	40·20	0·59*a*	23 06	...	..	0·72	100·29	Thomson, Kingston.

(*a*) Protoxide; (*b*) + 0·05 alumina; (*c*) hydrated; (*d*) + 0·31 lime; (*e*) lime; (*f*) sulphate. Nos. 1, 2, 7, fibrous; No. 3, foliated; No. 4, decomposed; and No. 5, radiated celestine.

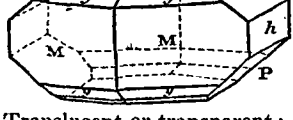
mon in the newer formations. The sulphur mines of Girgenti and other parts of Sicily furnish fine crystals. Large blue crystals come from Strontian island in Lake Erie; and smaller ones from Herrengrund in Hungary, Bex in Switzerland, Aust Ferry near Bristol, the Calton Hill, Edinburgh, and many parts of North America. It is found in amygdaloidal rocks at Monte Viale near Verona, and at Tantallan in East Lothian in Scotland. It is also found in fissures in the chalk and flint of Meudon near Paris; and in earthy nodules at Montmartre. It is very rare in mineral veins, as near Meissen.

The *Baryto-celestine* of Thomson occurs in radiating columnar or foliated masses, of a bluish-white colour, very brittle and friable. H. = 2·5; G. = 3·92. B.B. difficultly fusible. Chem. com. nearly $2\,\dot{S}r\,\ddot{S} + \dot{B}a\,\ddot{S}$, by analysis No. 8. It is found on Drummond Island in Lake Erie, and at Kingstown in Upper Canada. A celestine from Nörten in Hanover, in which Grüner found 26, and Turner 20·4 per cent. of sulphate of baryta, seems a similar variety.

225. STRONTIANITE, *Jameson;* Stronthian, *Werner;* Strontites, *Allan;* Carbonate of Strontian, *Phillips;* Strontiane carbonatée, *Hauy;* Peritomous Hal-Baryt, *Mohs.*

Rhombic; ∞P 117° 19′, $\breve{P}\infty$ 108° 12′; the crystals and macles similar to those of arragonite (fig. 178). Often acicular, pointed and in diverging groups. It also occurs in broad columnar and fibrous masses. Cleavage, prismatic along ∞P (*M*), and brachydomatic along $2\breve{P}\infty$ (*P*) (69° 16′) imperfect; H. = 3·5; G. = 3·6 — 3·8. Translucent or transparent; lustre vitreous, or resinous on the fractured surfaces; colourless, but often coloured light asparagus or apple-green, and more rarely greyish or yellowish. Streak white.

Fig. 178.



B.B. fuses in a strong heat only on very thin edges; intumesces in cauliflower-like forms, shines brightly, and colours the flame red. Easily soluble with effervescence in acids. The solution in hydrochloric acid, evaporated and then dissolved in alcohol, makes this burn with a carmine-red flame. Chem. com. $\dot{S}r\,\dot{C}$ with 30 carbonic acid and 70 strontia, but often contains carbonate of lime. Analyses.

	Strontia	Carb. acid.	Lime.	Mang. perox.	Watr.	Total.	
1	65·60	30·31	3·47	0·07*a*	0·08	99·53	Stromeyer, Strontian.
2	67·52	29·95	1·28	0·09	0·07	98·91	Do. Bräunsdorf, Freiberg.
3	92·87*b*	...	6·50*b*	...	0·25	99 62	Jordan, Clausthal (white).
4	92·75*b*	...	6·50*b*	...*c*	0·25	99·86	Do. Do. (yellow).
5	93·49*b*	...	6·28*b*	...	...	99·77	Thomson, Strontian (green).
6	91·08*b*	...	8·64*b*	...	...	99·72	Do. Do. (brown).

(*a*) With iron peroxide; (*b*) carbonate of; (*c*) + 0·36 carbonate of iron protoxide.

Strontianite was first found at Strontian in Argyllshire, forming veins in gneiss with barytes and galena. Large crystals occur at Leogang in Salzburg, but are rare. It is also found in Yorkshire in acute snow-white pyramids, at the Giant's Causeway in Ireland, at Bräunsdorf in Saxony in hexagonal or acicular prisms, at Hamm in Westphalia, the Harz, at Schoharie and other parts of the United States, and it is said at Popayan, Peru. The *Emmonite* is a mere variety from North America, in which Thomson found 12·5 per cent. carbonate of lime.

It is used to produce red fire in pyrotechnic exhibitions.

The *Stromnite* or *Barystrontianite* of Traill from Stromness in Orkney, occurs in yellowish-white, semitranslucent masses, with a faint pearly lustre, and crystalline structure; H. = 3·5; G. = 3·7. It contains 68·6 carbonate of strontia, 27·5 sulphate of baryta, 2·6 carbonate of lime, and 0·1 oxide of iron (= 98·8), *Traill;* but is perhaps only a mixture of strontianite and barytes.

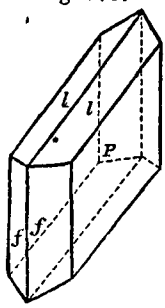
IV. Family.—Gypsum.

226. Gypsum, *Jameson;* Sulphate of Lime, *Phillips, &c.;* Gyps, Fraueneis, *Werner;* Chaux Sulfatée, *Hauy;* Gypse, *Beudant;* Prismatoidal Euclase Haloid, *Mohs.*

Monoclinohedric; C. = 81° 26′; the most common forms are ∞P 111° 14′, P 138° 44′, —P 143° 28′, and (∞P∞); several clinoprisms (∞P*m*) also occur. Two common combinations are ∞P (*f*). (∞P∞) (*P*). —P (*l*) (fig 179), and this with P; they appear partly short and thick, partly long and thin prismatic, partly also tabular.

Lenticular crystals often occur, formed essentially of —P . —½P∞ . 0P . ∞P, with the faces more or less curved. Macles are frequent, either with the twin axis the chief axis (fig. 83 above), especially in prismatic crystals; or with the twin axis the normal of —P∞, the lenticular crystals especially being conjoined by this law. The crystals are either imbedded singly or united in groups and druses. It is also found massive, in very coarse to very fine granular or compact aggregates; in fibrous crusts and veins; and in scaly or pulverulent masses. Cleavage, clinodiagonal very perfect, hemipyramidal along P, much less perfect; these two cleavages generally alternate, so that the planes, especially the latter, appear fibrous or striated; also orthodiagonal, but imperfect, and passing into the flat conchoidal fracture. Sectile, thin plates flexible (but not in all varieties); H. = 1·5 — 2 (lowest on *P*); G. = 2·2 — 2·4. Transparent or translucent. Lustre vitreous, on the more perfect cleavage planes pearly, on the pyramidal silky. Colourless and snow-white, but often coloured red, grey, yellow, brown, and more rarely greenish or bluish.

Fig. 179.



In the closed tube yields water B.B. becomes opaque and white; exfoliates and fuses to a white enamel, which is alkaline. On charcoal in the inner flame forms an hepatic mass. With fluor spar melts to a clear globule, becoming white and opaque when cold. It is soluble in 400 to 500 parts of water, which then shows traces of lime and sulphuric acid. It is scarcely more soluble in acids. Wholly decomposed by boiling in a solution of carbonate of potash. Chem. com. neutral sulphate of lime with two atoms water, or $\dot{C}a\,\ddot{S} + 2\,\dot{H}$ = 46·47 sulphuric acid, 32·65 lime, and 20·88 water. The following varieties contained

	Sulphuric acid.		Lime.		Water.		
Crystals, ...	44·8	...	33·0	...	21·0	= 98·8	Bucholz.
Fibrous, ...	44·13	...	33·00	...	21·00	= 98·13	Do.
Compact, ...	44·25	...	33·75	...	21·00	= 99·00	G. Rose.

Gypsum is a very common mineral, especially in the more recent sedimentary formations, and is even now forming either as a deposit from water holding it in solution, or from the decomposition of pyrites or sulphuret of iron, when the sulphuric acid combines with lime, or from the action of sulphurous vapours in volcanic regions on calcareous rocks. It is often imbedded in nests or reniform masses in clay or marl, more rarely makes part of mineral veins, but seldom,

if ever, forms veins by itself. The transparent crystals are named selenite, and fine specimens occur in the salt mines of Bex in Switzerland, in those of the Tyrol, Salzburg, and Bohemia, in the sulphur mines of Sicily, at Lockport in New York, and other places in North America, in the clay of Shotover Hill near Oxford, at Chatley near Bath, and many other localities. Fibrous gypsum occurs of remarkable beauty at Ilfeld in the Harz, in the compact gypsum of northern Germany, and at Matlock in Derbyshire. Compact white gypsum or alabaster is found in great beauty at Volterra in Tuscany, and also in the Harz. Massive or compact gypsum forms whole beds in the trias and permian red sandstones of many parts of Germany, France, Italy, and England, and is often associated with rock salt. In Nova Scotia it occurs with similar beds in the lower carboniferous formations.

The finer varieties are cut into various ornamental articles, as vases, and the so-called Roman pearls, chiefly distinguished from the true pearl by their specific gravity. Plaster of Paris, used for casts and other works of art, is formed by calcining the mineral and grinding it down to a fine powder, which forms a paste that soon hardens by absorbing the water driven off by the heat. It, however, loses this property when exposed to a temperature above 300° Fahrenheit, when it becomes similar to anhydrite. Gypsum is also used for glazing porcelain, in the manufacture of glass, as mortar and as manure, especially as a top-dressing for meadows.

227. ANHYDRITE, *Jameson*, *Phillips*; Muriazit, *Werner*; Karstenite, *Hausmann*; Chaux anhydro-sulfatée, *Hauy*; Prismatic Orthoclase Haloid, *Mohs*.

Rhombic; ∞P 100° 8′, $\breve{P}\infty$ 74°; combinations, $0P$. $\infty\bar{P}\infty$. $\infty\breve{P}\infty$. ∞P, also $0P$. $\infty\bar{P}\infty$. $\infty\breve{P}\infty$, with subordinate faces of P and $2\bar{P}2$. The crystals thick tabular, but on the whole very rare. It is chiefly found in coarse to fine granular, or almost compact aggregates, or with a columnar structure. Macles are rare. Cleavage, macrodiagonal and brachydiagonal both very perfect, basal perfect. H. = 3 — 3·5; G. = 2·8 — 3. Transparent or translucent. Lustre vitreous; on $\infty\breve{P}\infty$ pearly. Colourless or white; but often coloured bluish-white to violet-blue, reddish-white to flesh-red, or smoke-grey. Streak greyish-white. In closed tube gives no water. B.B. fuses difficultly to a white enamel. In charcoal in a strong reducing flame yields an hepatic mass. Fusible in borax to a clear glass, becoming yellow when cold. With fluor spar fuses readily to a clear globule, which becomes opaque when cold, and, on continuation of the heat,

intumesces and becomes infusible. Very slightly soluble in water or acids. Chem. com. $\dot{C}a\,\ddot{S}$, with 58·75 sulphuric acid and 41·25 lime. Analyses.

	Lime.	Sulph. acid.	Iron perox.	Silica.	Watr.	Total.	
1	43·06	59·78	0·10	0·25	...	103·19	Klaproth, Sulz (blue).
2	40·67	55·20	0·25	0·23	2·91*a*	100	Stromeyer, Ilfeld (fibrous).
3	41·41	56·78	0·03	0·26	0·94	99·42	Do. Vulpino (coarse scaly).
4	41·70	58·01	...	0·09	0·07	99·87	Do. Do. (fine scaly).

(*a*) + 0·09 carbonic acid and 0·04 bitumen.

Anhydrite occurs chiefly with rock salt and gypsum, or in the clays associated with these deposits. It is also found in some beds or veins with metallic sulphurets and other ores.

The crystalline varieties, or *muriacite*, occur in fine specimens in the salt mines of Bex in Switzerland, Hall in the Tyrol, and Aussee in Styria. Blue varieties are found at Sulz on the Neckar, and Bleiberg in Carinthia; compact or columnar masses at Ischel in Upper Austria, Berchtesgaden in Bavaria, Eisleben, and various parts of the Harz. The granular variety, or *Vulpinite* (Nos. 3, 4), from near Bergamo, is polished for ornamental purposes. The contorted species, or *Gekrösstein*, is chiefly found in clay in the salt mines of Wieliczka and Bochnia in Galicia. The blue varieties are occasionally used for ornamental purposes, but lose their colour by exposure to the sun.

Many varieties much resemble gypsum, but are distinguished by their higher hardness and specific gravity, and the three rectangular cleavages. On exposure it attracts moisture, and is converted into gypsum, the change extending through whole rocks. In such cases the surface is often covered by small crystals of the latter mineral.

228. POLYHALITE, *Stromeyer*, *Phillips*, *&c.*; Prismatic Brithyn-Salt, *Mohs*.

Rhombic, $\infty P = 115°$; usual combination $\infty\breve{P}\infty$. ∞P . $0P$, in long broad prisms; mostly combined in parallel columnar or fibrous aggregates. Cleavage, prismatic along ∞P imperfect. H. = 3·5; G. = 2·7 — 2·8. Translucent; pearly or resinous; colourless, but generally coloured pale flesh or brick-red, seldom grey. Weak bitter, and slightly saline taste. Soluble in water, leaving gypsum. B.B. fuses on charcoal to an opaque reddish bead, becoming white when cold. Chem. com. $2\,\dot{C}a\,\ddot{S} + \dot{M}g\,\ddot{S} + \dot{K}\,\ddot{S} + 2\,\dot{H}$, the name (*many-salts*) being derived from the number of its constituents. Analyses, next page.

	Sulph. lime.	Sulph. magnes.	Sulph. potassa.	Chloride sodium.	Iron perox.	Water.	Total.	
1	44·74	20·03	27·70	0·19	0·34	5·95	98·94	Stromeyer, Ischel.
2	45·42	20·59	28·10	0·11	0·33	5·24*a*	100	Rammelsberg, Aussee.

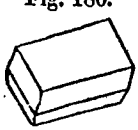
(*a*) + 0·20 silica.

Polyhallite occurs in the salt mines of Ischel in Austria, Aussee in Styria, and Berchtesgaden in Bavaria. No. 1 is the mean of several experiments, and No. 2 was a red variety. The similar grey and red minerals from Vic in Lorraine, analyzed by Berthier, were probably glauberite mixed with rock-salt, and the true polyhallite is not known from that locality.

229. GLAUBERITE, *Brongniart*, *Phillips*; Brongniartin, *von Leonhard*; Hemi-prismatic Brithyn-salt, *Mohs*.

Monoclinohedric, C = 68° 16′, ∞P 83° 20′, —P 116° 20′ (116° 30′, *Dufrénoy*), 0P : ∞P = 104° 15′. Usual combination 0P . —P, sometimes with ∞P (fig. 180). Crystals generally thick tabular, from predominance of 0P. Cleavage, basal perfect, along ∞P traces. H. = 2·5 — 3; G. = 2·75 — 2·85. Translucent; lustre vitreous to resinous; colourless, but yellowish or greyish-white. Taste slightly saline and bitter. B.B. decrepitates violently, and melts to a clear glass. On charcoal in the inner flame forms a hepatic mass. Decomposed by water, which removes the sulphate of soda and leaves the sulphate of lime, and hence the crystals become opaque. In a large quantity of water it is almost entirely soluble. Chem. com. $\dot{N}a\ddot{S} + \dot{C}a\ddot{S}$, with 51 sulphate of soda and 49 sulphate of lime. Analyses.

Fig. 180.



	Sulphate of soda.	Sulphate of lime.	Chloride of sodium.	Clay, with iron.	Total.	
1	51	49	...	...	100	Brongniart, Villarubia.
2	48·50	46·60	1·20	2·70	99·00	Dufrénoy, Vic, Lorraine.
3	48·6	51·0	...	...	99·6	v. Kobell, Berchtesgaden.

This rare salt occurs in salt and clay, especially at Villarubia near Ocana in Spain, at Vic, and Berchtesgaden. Also it is said in gypsum near Brugg in Aargau, and more doubtfully at Aussee and Ischel in Austria. In a variety from Tarapaca in Peru, Hayes found 67·22 sulphuric acid, 21·32 soda, 20·68 lime, and 0·44 iron (= 99·66). Sir D. Brewster states that it has one axis of double refraction for violet, and two axes for red light.

230. PHARMACOLITE, *Hausmann*, *Phillips;* Arsenikblüthe, *Werner*, in part; Chaux arseniatée, *Hauy;* Hemiprismatic Euclase Haloid, *Mohs.*

Monoclinohedric, C = 65° 4′, ∞P 117° 24′, —P 139° 17′; usual combination 0P . (∞P∞) . ∞P . —P. The crystals, prismatic and lengthened in the direction of the clinodiagonal, are small; often short acicular or capillary, and united in minute reniform groups or crusts, with a radiated fibrous texture. Cleavage, clinodiagonal very perfect. Sectile, and in thin laminæ flexible. H. = 2 — 2·5; G. = 2·6 — 2·8. Translucent; lustre vitreous, on (∞P∞) pearly; the fibrous masses silky. Colourless and white, but sometimes coloured rose-red or green. Yields water in the closed tube; B.B. fuses in the forceps in the outer flame to a white enamel; in the inner flame on charcoal gives arsenic fumes, and fuses to a semitranslucent, sometimes bluish, grain, colouring the flame blue. Easily soluble in acids. Chem com. $\dot{C}a^2\ \ddot{A}s + 6\ \dot{H}$ = 51 arsenic acid, 25 lime, and 24 water. Analyses.

	Arsenic acid.	Lime.	Magnesia.	Cobalt oxide.	Watr.	Total.	
1	50·54	25·00	...	...	24·46	100	Klaproth, Wittichen.
2	45·68	27·28	...	...	23·86	96·82	John, Andreasberg.
3	79·01 *a*	...	...	...	20·99	100	Turner, unknown.
4	51·58	23.59	...	1·43*b*	23·40	100	Rammelsberg, Glücksbrunn.
5	46·97	24.65	3·22	1·00	23·98	99 82	Stromeyer, Riechelsdorf.

(*a*) With lime; (*b*) with peroxide of iron.

This mineral much resembles the arsenious acid, but is distinguished by being insoluble in water. It is found with silver ores at Andreasberg in the Harz; at Glücksbrunn in Thuringia; and Riechelsdorf and Biber in Hessia in cobalt veins in the kupferschiefer; at Joachimsthal in Bohemia, and Markirchen in Alsace, in gneiss; and at Wittichen in the Schwarzwald in veins in granite, along with arsenic and cobalt ores. It seems a recent formation, produced by the decomposition of ores of arsenic, the acid from which enters into union with lime. A singular proof of this is furnished by a specimen possessed by Hausmann from Riechelsdorf, in which the botryoidal concretions have formed on a human hair. In others from Joachimsthal, crystals of realgar are changed into pharmacolite.

The *Picropharmacolite* of Stromeyer (No. 5) differs chiefly in containing magnesia, and a rather smaller proportion of the arsenic acid, but can hardly be considered a distinct species.

The *Roselite* of Lévy, according to Haidinger, forms very small monoclinohedric macles (a prism = 47° 12′), with a perfect cleavage in one direction. Lustre vitreous; colour deep rose-red; streak

white. According to Children, it consists of arsenic acid, oxide of cobalt, lime, magnesia, and water. In the closed tube it yields water, and becomes black. B.B. with borax in the oxidating flame forms a deep blue glass. It is probably a distinct species, but still very imperfectly known, only a few specimens having been found attached to compact quartz at Schneeberg in Saxony.

231. HAIDINGERITE, *Turner.*

Rhombic, ∞P 100°, $\breve{P}\infty$ 127°, $\frac{1}{2}\breve{P}\infty$ 147°, with $\infty\breve{P}\infty$ and $\infty\bar{P}\infty$, are the prevailing forms. The crystals are short prismatic, small, and united in drusy crusts. Cleavage, brachydiagonal very perfect; sectile, in thin plates flexible. H. = 2 — 2·5; G. = 2·8 — 2·9. Transparent or translucent; colourless and white. Chemical characters and composition like pharmacolite, but with only 3 atoms water. Turner's analysis gave 85·68 arseniate of lime and 14·32 water. Only one specimen known, found with pharmacolite, probably at Joachimsthal in Bohemia.

232. BERZELIITE, *Kühn;* Magnesian Pharmacolite, *Dana;* Chaux arséniatée anhydre, *Dufrénoy.*

Massive, with traces of cleavage in one direction. Brittle; H. = 5·5; G. = 2·52. Translucent or only on the edges; lustre resinous; colour honey-yellow or yellowish-white. B.B. infusible, but becomes grey, and shows reaction for arsenic, and with soda for manganese. Soluble in nitric acid. Chem. com. $\dot{C}a^3\,\dddot{A}s + \dot{M}g^3\,\dddot{A}s$ but with part of the magnesia replaced by manganese protoxide. Analyses.

	Arsenic acid.	Lime.	Magnesia.	Mang. prot.	Loss by heat.	Insoluble.	Total.	
1	58·51	23·22	15·68	2·13	0·30	...	99·84	Kühn.
2	56·46	20·96	15·61	4·26	2·95	0·23	100·47	Do.

It occurs at Longbanshytta in Sweden with hedyphane, which it much resembles.

V. FAMILY.—ROCK SALT.

233. ROCK SALT; Chloride of Sodium; Muriate of Soda, *Phillips, &c.;* Steinsalz, Kochsalz, *Werner, &c.;* Soude muriatée, *Hauy;* Salmare, *Beudant;* Selgemme, *Dufrénoy;* Hexahedral Rock Salt, *Mohs.*

Tesseral; almost always $\infty O\infty$, rarely with faces of other forms. Generally in granular and fibrous masses, the latter forming crusts

or plates; also disseminated. Cleavage, hexahedral very perfect. Fracture conchoidal; rather brittle; yields slightly when scratched with the nail; H. = 2; G. = 2·1 — 2·2. Transparent or translucent; lustre vitreous; colourless or white, but often coloured red, yellow, grey, and rarely blue. Taste saline. In the closed tube decrepitates, and yields a little water. B.B. on charcoal fuses and partly evaporates, partly sinks into the support. On platina wire with soda fuses to a clear mass, colouring the flame yellow. Added to a bead of salt of phosphorus with copper-oxide, colours the flame blue. Very soluble in water. Chem. com. Na Cl, with 60 chlorine and 40 sodium, but often with various impurities.

In the Cheshire rock salt Henry found 98·32 chloride of sodium, 0·02 chloride of magnesium, 0·65 sulphate of lime, and 0·01 chloride of calcium, with 1·00 of insoluble matter. According to Mr W. Nicol, it also contains irregular cavities, full of a concentrated solution of chloride of magnesium, and a little chloride of calcium. Vogel, in the salt from Berchtesgaden and Hallein, found a little chloride of potassium; in that from Hall and other salt springs chloride of ammonium. The red colour of rock salt is in general caused by peroxide of iron, but in that from Cardona arises, according to Marcel de Serres and Jolly, from enclosed infusoria. The decomposition of salt, by attracting moisture from the atmosphere, is caused by the mixture of chlorides of magnesium and calcium, as the rock salt which does not contain these substances, is not liable to deliquesce. Melloni found that polished plates of pure rock salt have a remarkable capacity of transmitting radiated heat, 0·923 of the vertical rays passing through them unabsorbed.

This important mineral is very widely disseminated, sometimes in thick beds or large masses, with clay, anhydrite, and gypsum in various formations, at other times as an efflorescence, covering extensive tracts of country. The most celebrated European deposits occur at Wieliczka and other parts of Galicia, in Hungary, Siebenburg, Moldavia, Styria, Salzburg (Hallein), in Tyrol (Hall), also in Bavaria, Wurtemberg, Switzerland (Bex), and Spain, especially at Cardona, where it forms a whole mountain. In England the chief deposits are in Cheshire, as at Northwich, where it occupies a basin-shaped hollow, and consists of orbicular masses with concentric coats, and is often so pure as to require no further preparation. As an efflorescence it is most abundant on the sandy plains on the Rio de S. Francisco, and Rio Paraguay in Brazil; at the foot of the Atlas Mountains in Africa; in Abyssinia, where the salt plain of Dalkali is said to extend for four days' journey; in certain parts of Arabia, where it is used as a building material; and in the Steppes round the Caspian Sea and Lake Aral. It is also found as a sublimation among

the lavas of Vesuvius, and along with sulphur both in Switzerland and Sicily. Many springs and lakes contain salt in solution; and in the water of the ocean it amounts to three or four per cent. Its various uses are too well known to require notice. (Compare, Karsten's Lehrbuche der Salinenkunde, Berlin, 1846.)

A species of rock salt at Wieliczka decrepitates when dissolved in water. This arises from its containing vesicles full of compressed gases, which burst as the crust is dissolved. H. Rose found the gas to vary in amount, and also in composition, but in one case it consisted in 100 volumes of—24 hydrogen, 17 carbonic acid gas, and 59 carburretted hydrogen; and Berzelius supposes some carbonic acid also to remain dissolved in the water. In other respects the mineral does not differ from common salt. The *Martinsite* of Karsten, found in boring for rock salt at Stassfurth in Prussian Saxony, also slightly decrepitates, and contains 90·98 chloride of sodium and 9·02 sulphate of magnesia, or in the proportion of 10 atoms of the former to one of the latter.

Sylvin, or chloride of potassium, found according to Smithson as a sublimation on Vesuvius, and by Vogel in the rock salt of Hallein and Berchtesgaden, agrees in most characters with rock salt (G. = 1·9 — 2), and probably occurs with it in other places. It has also been found in sea water, and in iron furnaces either crystallized in cubes or compact.

234. ALUM, *Phillips, &c.*; Alaun, *Werner*; Alumine sulfatée, *Hauy*; Octahedral Alum-salt, *Mohs.*

Tesseral; O, sometimes with ∞O∞ and ∞O. Generally occurs in crusts, with a parallel fibrous structure, or as an efflorescence. Macles rare, united by a face of O as in fig. 76 above. Cleavage, octahedral, imperfect. Fracture conchoidal. H. = 2 — 2·5; G. = 1·75 — 1·9. Translucent; colourless and white. Taste sweetish astringent. Easily soluble in water. B.B. generally evolves sulphurous fumes, and the residue becomes blue with cobalt solution. Chem. com. generally $\dot{R}\,\dot{S} + \ddot{A}\dot{l}\,\dot{S}^3 + 24\,\dot{H}$. There are several varieties, differing slightly in external and other characters, according as one isomorphic element is replaced by another.

(*a*) *Potash-alum* (*Kalialaun*, v. Kobell; *Alun*, Dufrénoy), with $\dot{R} = \dot{K}$, and 33·52 sulphuric acid, 10·86 alumina, 9·96 potash, and 45·66 water. In the closed tube it fuses, intumesces, and yields much water. It occurs in the alum slates of various formations, in deposits of brown coal, and near volcanic solfataras. Among its more remarkable localities may be mentioned the transition rocks of Sweden, Norway (at Christiana), and Scotland; the coal formation,

as in the burning hill of Duttweiler near Saarbruck, and at Hurlet near Paisley, and Campsie, in Scotland; in the lias near Whitby in Yorkshire; in the brown-coals of Hessia and the Rhine; in the volcanic formations of the Lipari islands, Sicily, and the Azores. In many cases it is a recent produce of decomposing sulphurets, where alumina and potash are present.

(*b*) *Ammonia-alum* (*Amoniakalaun*, v. Kobell; *Alun ammoniacal*, Dufrénoy), in which $\dot{N}H^3\,\ddot{S}$ replaces $\dot{K}\,\ddot{S}$, with about 4 per cent. ammonia and 48 water. In the closed tube it forms a sublimate of sulphate of ammonia; and, heated with soda, yields ammoniacal odours. It occurs in thin layers in the brown coal of Tschermig in Bohemia. Analyses Nos. 1, 2, 3.

(*c*) *Soda-alum* (*Natrumalaun*, v. Kobell; *Alun sodifère*, Dufrénoy), with $\dot{R} = \dot{N}a$, and 7 soda and 48 water. It agrees in general with potash-alum, but is more easily soluble in water. It is found in St Juan near Mendoza in South America (No. 4), near the Solfatara at Naples, and in the island of Milo. No. 5 is another soda-alum, G. = 1·584, found in white or red fibrous masses in Southern Peru; it is soluble in water, and corresponds to $2\,\dot{N}a\,\ddot{S} + 3\,\ddot{A}l\,\ddot{S}^2 + 10\,\dot{H}$.

(*d*) *Magnesia-alum* (*Talkerdealaun*, v. Kobell; *Alun magnésien*, Dufrénoy), in which $\dot{R} = \dot{M}g$, sometimes with $\dot{M}n$. When newly exposed it is highly translucent and silky, but soon changes in the air. No. 6 is nearly a pure magnesia-alum, found about six inches thick covering the floor of a cave near Bosjesman's river in South Africa. No. 7 is the *Pickeringite* of Hayes, from Iquique in Peru, white, silky, and fibrous. No. 8, again, is a similar manganese-alum from Lagoa Bay in South Africa.

(*e*) *Iron-alum* (*Feather-alum; Federalaun; Alun de plume*, Dufrénoy), with $\dot{R} = \dot{F}e$. To this belongs No. 9 from an unknown locality, No. 10 from Hurlet near Paisley, and No. 11 from the quicksilver mines of Mörsfeld in Rhenish Bavaria. No. 12, the Hversalt found on decomposing volcanic rocks at Krisuvig in Iceland, is remarkable for the alumina being partly replaced by iron peroxide. Some so-called rock-butter (Bergbutter) seem similar alums.

(*f*) *Voltaite*, Sacchi, $= 3\,(\dot{F}e, \dot{K}, \dot{N}a)\,\ddot{S} + (\ddot{F}\dot{e}, \ddot{A}l)\,\ddot{S}^3 + 12\,\dot{H}$, occurs in octahedrons of a black colour, with greenish-grey streak, in the Solfatara of Pozzuoli; and, according to Dufrénoy, also as a residuum of the distillation of sulphur. Though closely agreeing in external characters with the alums, it differs much from them in chem. com. (Nos. 13, 14), and should probably form a distinct species. It is also more difficultly soluble in water than alum.

Analyses, next page.

	Sulph. acid.	Alumina.	Potash.	Soda.	Ammonia.	Magnesia.	Iron prot.	Mang. prot.	Watr.	Total	
1	36·00	12·14	...	...	6·58	0·28	...	...	45·00	100	Pfaff.
2	38·53	12·34	...	...	4·12	...	...	...	44·96	100	Lampadius.
3	36·06	11·60	...	...	3·72	0·12	...	...	48·39	99·89	Stromeyer.
4	37·85	12·04	...	7·58	...	...	0·21	... *e*	42·04	100	Thomson.
5	32·95	22·55	...	6·50*b*	...	...	...	...	39·20	101·20	Do.
6	36·77	11·51	0.21*a*	...	...	3·69	...	2·62	45·74	100·09	Stromeyer.
7	36·32	12·13	...	...	...	4 68	0·43*c*	...	45·45	99·74	Hayes.
8	32·79	10·65	...	...	...	1·08*b*	...	7·33	48·15	100	Anjohn.
9	34·4	8·8	...	...	...	0·8	12·0	...	44·0	100	Berthier.
10	30·9	5·2	...	...	...	...	20·7	...	43·2	100	Phillips.
11	36·03	10·91	0·43	...	...	0·24	9·37	...	43·02	100	Rammelsberg.
12	35·16	11·22	...	...	...	2·19	4·57	1·23*d*	45·63	100	Forchhammer.
13	45·67	3·27	5·47	...	...	...	28·69	... *f*	15·77	99·33	Dufrénoy.
14	48·32	2·20	4·04	0·25	...	...	11·60	17·65*d*	15·94	100	Abich.

(*a*) Chloride of potassium; (*b*) sulphate; (*c*) with manganese protoxide + 0·13 lime and 0·60 hydrochloric acid; (*d*) peroxide; (*e*) + 0·02 silica and 0·26 lime; (*f*) + 0·46 remainder.

235. ALUNOGENE, *Beudant;* Sulphate of Alumina, *Phillips;* Alumine sulfatée, *Hauy;* Halotrichite, *Glocker;* Haarsalz, *Werner;* Hair salt, Feather alum, in part.

Crystallization unknown; occurs in capillary or acicular fibres forming crusts, botryoidal or reniform masses, or rarely in granular aggregates. H. = 1·5—2; G. = 1·6—1·7. Lustre silky; colour white, inclining to green or yellow. Tastes like alum. B.B. in closed tube intumesces, yields much water, and is infusible. With cobalt solution gives a pure blue, when it contains no iron. Easily soluble in water. When to the cold saturated solution a similar solution of sulphate of potash is added, crystals of alum are formed. Chem. com. $\ddot{A}i\ \ddot{S}^3 + 18\ \dot{H}$, with 36·05 sulphuric acid, 15·40 alumina, 48·55 water. Analyses.

	Sulph. acid.	Alumina.	Watr.	Iron protoxide.	Mang. protoxide.	Lime.	Magnesia.	Potash.	Silica.	Total.	
1	36·40	16·08	46·60	0·004	...	0·002	0·004	...	...	99·01	Boussingault.
2	35·68	14·38	49·34	...	...	...	...	...	...	100	Do.
3	29·0	15·0	51·8	1·2*a*	...	...	...	...	(3·0)*b*	100	Mill.
4	40·31	14·98	40·94	...	...	...	0·Ω	0·26	1·13*c*	100	Hartwall.
5	36·97	14·63	44·64	2·58*a*	..	...	0·14	...	1·37	100·33	H. Rose.
6	35·82	15·57	48·61	...	...	...	...	...	...	100	Rammelsberg.
7	37·38	14·87	45·16	2·46	....	0·15	...	0·22	...	100·24	Do.
8	35·71	12·78	47·02	0·67	1·02	0·64	0·27	0·32	...	98·43	Do.
9	35·64	11·23	48·85*d*	0·72	0·31	0·45	1 91	0·47	0·43	100	Do.
10	58·58	38·75	...	2·78*e*	...	...	...	...	...	100·11	Göbel.
11	35·63	17·09	36·70	...	...	...	...	...	0·50 *f*	99·66	Herapath.
12	12·9	41·5	42·1	...	...	...	...	...	3·5	100	Berthier

(*a*) Peroxide; (*b*) earthy matter; (*c*) + 1·13 soda and 0·40 hydrochloric acid; (*d*) with loss; (*e*) sulphate of; (*f*) earthy matter + 0·04 oxide of copper.

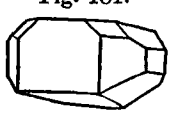
These analyses represent the chief varieties of this mineral. They are of specimens from (No. 1) Saldana in Colombia; (2) the crater of the volcano of Pasto; (3) deposited by the hot springs of Chivachy

near Bogota (the Davyt); (4) Pyromeni on the volcanic island Milo in the Grecian Archipelago; (5) province of Coquimbo in Chili, where it is associated with many sulphates of the oxides of iron; (6) brown coal of Kolosoruk near Bilin; (7) brown coal of Friesdorff near Bonn; (8) alum-slate of Potschappel near Dresden; (9) the aluminous earth of Freienwalde. Nos. 8 and 9 are so-called hair salt, and Rammelsberg from his own investigations would class with them the hair salt from Bodenmais, and the natural alum of Socorro near Bogota. No. 10 is a white weathered salt from Ararat without the water, which was not determined. No. 12 is a salt very abundant near Adelaide in New South Wales; and 13 a peculiar sulphate of alumina from Huelgoëth in Brittany, probably a mixture. These are the chief known localities of this mineral, but it is probably abundant in many localities, where not distinguished from other alums. It often forms in volcanic solfataras, or in clays, and felspar rocks containing pyrites; and is a frequent efflorescence on the walls of quarries and mines.

236. GLAUBER-SALT; MIRABILITE, *Haidinger;* Sal-mirabile, *of older Chemists;* Sulphate of Soda, *Phillips;* Soude sulfatée, *Hauy;* Exanthalose, *Beudant;* Prismatic Glauber-Salt, *Mohs.*

Monoclinohedric, C = 72° 15′, ∞P 86° 31′, P 93° 12′, (P∞) 80° 38′. The crystals generally lengthened in the direction of the orthodiagonal, and formed predominantly by 0P and ∞P∞ (fig. 181); but in general only occurs in efflorescent crusts. Cleavage, orthodiagonal very perfect; fracture conchoidal; H. = 1·5 — 2; G. = 1·4 — 1·5. Pellucid and colourless; taste cool, saline, and bitter; easily soluble in water; decomposes readily in the atmosphere, and falls into powder. B.B. in closed tube melts in its water of crystallization. The anhydrous salt fuses on charcoal, and becomes hepatic. Chem. com. $\dot{N}a\dot{S} + 10\dot{H}$ = 19·3 soda, 24·7 sulphuric acid, and 56 water.

Fig. 181.



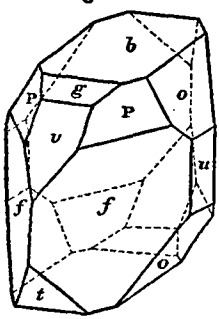
Occurs chiefly as an efflorescence in quarries and on old walls, as in the salt mines of Aussee, Ischel, and Hallstadt in Upper Austria; at Hallein in Salzburg; on Vesuvius in the lava of 1813; also in Hungary, Switzerland, Spain, and other countries. It is deposited in great abundance from the hot springs at Carlsbad; and is found in those of Eger and Seidlitz in Bohemia, and in many other mineral waters. It is likewise procured from salt springs, or forms a crust or efflorescence on the border of salt lakes in Egypt, Southern Russia, and other countries. When purified, it is used in medicine, and in some countries in preparing glass and soap.

A solution of Glauber salt in an open vessel at ordinary temperatures crystallizes in prisms with four or six sides, and contains 10 atoms water; at 86° Fahr. it forms rhombic prisms and rhombic pyramids, and the salt is anhydrous. In a closed vessel a solution of two parts of the salt in one of warm water forms, when cooling, transparent crystals with 8 atoms water, which, when touched, immediately become opaque. (*Hutstein*).

237. MELANTERITE, *Beudant;* Green Vitriol; Iron vitriol; Sulphate of Iron, *Phillips;* Eisen-Vitriol, *Hausmann;* Fer sulfaté, *Hauy;* Copperas, *Dana;* Hemiprismatic vitriol salt, *Mohs.*

Monoclinohedric, C = 75° 40′; ∞P (*f*) 82° 21′, —P (*P*) 101° 35′, (P∞) (*o*) 69° 17′, (∞P∞) (*u*); the most common combination is ∞P . 0P, either alone or with other forms, fig. 182; and hence the crystals appear short prismatic or thick tabular. It seldom occurs distinctly crystallized, but chiefly in stalactitic, reniform, or botryoidal crusts and masses. Cleavage, basal very perfect, prismatic along ∞P less so; H. = 2; G. = 1·8 — 1·9. Translucent, rarely transparent; lustre vitreous; colour leek or mountain-green, often with a yellow coating on the surface; streak white; taste sweetish astringent; very soluble in water. B. B. in closed tube melts in the water of crystallization, which then evaporates, and leaves a white anhydrous salt. Chem. com. $\dot{Fe}\,\ddot{S} + 7\,\dot{H} = 26{\cdot}0$ protoxide of iron, 28·8 sulphuric acid, and 45·2 water.

Fig. 182.



This salt is a recent production from the decomposition of iron pyrites, and is manufactured by exposing this mineral to the atmosphere, and occasionally moistening it. Crystallized varieties have been found at Bodenmais in Bavaria, at Rammelsberg near Goslar in the Harz, and at Fahlun. Other localities are Schemnitz in Hungary, Bilin in Bohemia, and Hurlet near Paisley in Scotland. It is used in dyeing, in manufacturing ink, Prussian blue, and sulphuric acid. The residue of distillation in the last process, named the *colcothar of iron*, is used as a red pigment, and for polishing steel.

238. BOTRYOGENE, *Haidinger, Phillips;* Red Vitriol; Fer sulfaté rouge, *Dufrénoy;* Hemiprismatic Botryogen-salt, *Mohs.*

Monoclinohedric; ∞P 119° 56′; the most frequent combination is ∞P . (∞P2) . 0P . (½P∞), and the small crystals always appear

very short prismatic. More common in small botryoidal and reniform masses, with a fine columnar texture. Cleavage, prismatic along ∞P, rather distinct. Sectile; H. = 2 — 2·5; G. = 2 — 2·1. Translucent, vitreous lustre; colour hyacinth-red, orange-yellow, and yellowish-brown; streak ochre-yellow. Taste slightly astringent. Partially soluble in water, leaving a yellow ochre behind. B.B. intumesces and evolves water in the closed tube; when ignited gives out sulphurous fumes, and then acts like peroxide of iron. Analyses.

	Sulph. of iron protox.	Sulph. of iron peroxide.	Sulph. of magnesia.	Sulph. of lime.	Water & loss.	Total.	
1	6·77	35·85	26·88	2·22	28·28	100	Berzelius, Fahlun.
2	6·85	39·92	17·10	6·71	31·42	100	Do. Bo.
3		48·3	20·8	...	30·9	100	Do. Do.

Berzelius considers the sulphates of lime and magnesia as not essential, and proposes the formula $\dot{Fe}^3\,\ddot{S}^2 + 3\dot{\ddot{F}}\dot{e}\,\ddot{S}^2 + 36\,\dot{H}$. It occurs with gypsum and epsomite at Fahlun in Sweden.

239. COPIAPITE, *Haidinger*; Basisches schwefelsaures Eisenoxyd, *Rammelsberg*.

(*a*) *Foliated.* Occurs in six-sided tables, but crystal-system uncertain, and also in granular masses. Cleavage, basal perfect. Translucent; lustre pearly; colour yellow. Chem. com. $\dot{\ddot{F}}\dot{e}^2\,\ddot{S}^5 + 18\,\dot{H}$. Occurs at Copiapo in Coquimbo in Chili. Analysis No. 1.

(*b*) *Radiated.* Occurs incrusting the former, in masses with a radiated fibrous texture. Colour dirty greenish-yellow. Chem. com. $2\,\dot{\ddot{F}}\dot{e}\,\ddot{S}^2 + 21\,\dot{H}$. Analysis No. 2.

	Sulph. acid.	Iron perox.	Alumina.	Lime.	Magnesia.	Silica.	Watr.	Total.	
1	39·60	26·11	1·95	...	2·64	1·37	29·67	101·34	H. Rose.
2	31·73	28·11	...	1·91	0·59	1·43	36·56	100·53	Do.
3	38·9	34·4	...	...	...	...	26·7	100	Prideaux.
4	32·11	46·74	...	0·64	7·88*a*	...	13·56	100·94	Rammelsberg.
5	32·45	49·63	...	...	5·37*b*	...	13·11	100·39	Scheerer (mean of 2).
6	6·00	80·73	...	...	...	...	13·57	100·30	Do.
7	42·90	53·30	...	...	...	...	3·96	100·16	Meillet.

(*a*) Potash; (*b*) Soda.

Both substances are probably mixtures of several salts, as Berzelius has intimated. To these may be added,

Fibroferrite of Prideaux also from Chili, No. 3 a corrected analysis, the original having contained 10 per cent. sulphur, earthy matter, and

loss. It is partially soluble in warm water; intumesces in hydrochloric acid, becomes deep yellowish-red, and at length is dissolved, leaving the sulphur and earth.

Gelbeisenerz (Yellow Iron-ore) of Breithaupt, No. 4, from the brown coal at Kolosoruk in Bohemia, and No. 5 a similar compound from Modum in Norway. They occur in reniform, or compact and earthy masses; H. = 2·5 — 3; G. = 2·7 — 2·9. Opaque; lustre weak; colour ochre-yellow. In the closed tube they become red, and evolve first water, then sulphurous acids. Not soluble in water, with difficulty in hydrochloric acid. They are perhaps mixtures of various salts produced during decomposition. No. 6 is a dark-brown salt of iron also from Modum, and still more probably a mixture.

Apatelite of Meillet, No. 7, occurs in small reniform earthy masses of a yellow colour in clay, at Auteuil near Paris. It is similar to the yellow iron ore, but has a different composition, $= 2\,\dddot{F}e^2\,\ddot{S}^3 + 3\,\dot{H}$. The *Vitriol ochre* of Berzelius occurs at Fahlun with botryogen, and is an earthy ochre-yellow substance. Its composition, according to Berzelius, is $\dddot{F}e^2\,\ddot{S} + 6\,\dot{H}$ with 16·00 sulphuric acid, 62·46 iron peroxide, and 21·54 water. When heated it loses water, becomes brown-red, and when highly ignited evolves sulphurous fumes. A similar salt seems to occur in some of the ochreous mixtures at Rammelsberg near Goslar in the Harz. At the latter place a mixture of the sulphates of the protoxide and peroxide of iron, with sulphates of copper, zinc, and other metals, is named *Misy*.

240. COQUIMBITE, *Breithaupt*, *Dana*, *Dufrénoy*; Neutrales schwefelsaures Eisenoxyd, *Rammelsberg*.

Hexagonal, P 58°; the crystals are thick tabular or short prismatic combinations of 0P with ∞P and P. Usually in granular aggregates. Cleavage, prismatic along ∞P imperfect; H. = 2 — 2·5; G. = 2 — 2·1. Colourless, white, also brown, yellow, red, and blue; taste astringent. B.B. in closed tube evolves water, and then sulphurous vapours, the remainder acting like iron peroxide. Chem. com. $\dddot{F}e\,\ddot{S}^3 + 9\,\dot{H}$, with 28·5 iron peroxide, 43·6 sulphuric acid, and 28·9 water. Analyses.

	Sulph. acid.	Iron perox.	Alumina.	Lime.	Magnesia	Silica.	Watr.	Total.	
1	43·55	24·11	0·92	0·78	0·32	0·31	30·10	100·04	H. Rose.
2	43·55	25·21	0·78	0·14	0·21	0·37	29·98	100·24	Do.
3	41·37	26·79	1·05	...	0·30	0·82	29·40	99·68	J. H. Blake.

This salt is found in beds or veins in felspar porphyry, or trachyte, in Chili near Copiapo, and in Bolivia near Calama, where it forms the chief part of a hill. No. 1 was crystallized; No. 2 fine granular;

and No. 3, according to Blake, was a regular octahedron, in which case the mineral must be dimorphous.

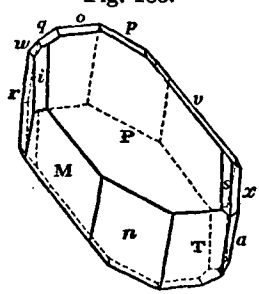
241. TECTIZITE, *Breithaupt;* Braunsalz, *Naumann.*

Rhombic, dimensions unknown. It forms small pyramidal and acicular crystals, sometimes in scopiform groups, or massive. Rather soft and friable; H. = 1·5 — 2; G. = 2 nearly. Lustre vitreous or resinous; colour clove-brown. Easily soluble in water, and attracts moisture readily from the atmosphere. B.B. fuses in its water of crystallization. Seems to be a hydrous sulphate of peroxide of iron, but composition unknown. Found in Saxony at Graul near Schwarzenberg, and at Bräunsdorf in the Erzgebirge.

242. CYANOSE, *Beudant;* Blue Vitriol; Sulphate of copper, *Phillips;* Kupfervitriol, *Hausmann;* Cuivre sulfatè, *Hauy;* Tetartoprismatic vitriol salt, *Mohs.*

Triclinohedric; the crystals are very unsymmetric, and in considerable variety, but $\infty'P \cdot \infty P' \cdot P'$ forms the basis of most of the combinations, to which 0P, $\infty\breve{P}\infty$, and $\infty\check{P}\infty$ are very frequently added. The latter two faces ($n : r$) form an angle of 79° 19′; P′ (*P*) is inclined to $\infty P'$ (*T*) 127° 40′, to $\infty\breve{P}\infty$ (*n*) 120° 50′, to $\infty\check{P}\infty$ (*r*) 103° 27′, and ∞P (*T*) to $\infty'P$ (*M*) 123° 10′ (fig. 183). It seldom occurs naturally in distinct crystals, but more often in stalactitic, reniform, or other aggregates, and as an incrustation or pulverulent coating. Cleavage, along $\infty P'$ and $\infty'P$ very imperfect. Fracture conchoidal; H. = 2·5; G. = 2·2 — 2·3. Translucent; lustre vitreous; colour Berlin-blue to azure-blue; taste very nauseous; readily soluble in water, from which metallic copper is precipitated by iron. B.B. in the closed tube it evolves water, and becomes white; and on charcoal, especially with soda, is easily reduced to metallic copper. Chem. com. $\dot{C}u\,\ddot{S} + 5\,\dot{H}$, with 32 protoxide of copper, 32 sulphuric acid, and 36 water.

Fig. 183.



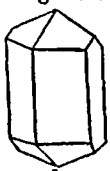
This salt is a secondary production, especially from copper pyrites, and is very abundant in solution in the water of some mines, as those of Rammelsberg near Goslar in the Harz, Schemnitz, Orawitza, and Neusohl in Hungary, Klausen in Tyrol, Fahlun, Rio Tinto in Spain, in Anglesea, Cornwall, and Wicklow in Ireland, and many other places. It also occurs among volcanic products, as on the lava of

Vesuvius. It is seldom found pure; but, where in sufficient abundance, is used in the manufacture of blue vitriol. The larger part of this substance employed in the arts is, however, formed artificially,—either by the roasting and lixiviation of pyrites and other ores of copper,—by treating these or the metal with sulphuric acid,—or as a residuary product of metallurgic operations. It is used in dyeing, and in forming blue and green pigments.

243. GOSLARITE, *Haidinger;* Sulphate of Zinc, *Phillips;* Zinkvitriol, *Hausmann;* Zinc sulfaté, *Hauy;* White vitriol, *Dana;* Prismatic vitriol salt, *Mohs.*

Rhombic; ∞P 90° 42′, isomorphous with epsomite; usual combination ∞P . ∞P̆∞ . P (fig. 184). The crystals are prismatic and lengthened along the chief axis. It is mostly found in granular masses, or stalactitic, reniform, and encrusting. Cleavage, brachydiagonal perfect. H. = 2 — 2·5; G. = 2 — 2·1. Pellucid; lustre vitreous; colour white, inclining to grey, yellow, green, or red. Taste nauseous astringent. Very easily soluble in water. In the closed tube yields water, and, ignited with charcoal powder, sulphuric acid. Chem. com. when pure $\dot{Zn}\dot{S} + 7\,\dot{H}$. Analyses.

Fig. 184.



	Zinc oxide.	Mang. perox.	Sulph. acid.	Watr.	Total.	
1	27·5	0·5	22·0	50·0	100·0	Klaproth, Goslar.
2	21·74	6·52	71·74*a*	...	100·00	Hausmann, Do.
3	25·67	4·33	21·60	46·60*b*	99·94	Schaub, Cornwall.

(*a*) With water; (*b*) + 1·00 copper protoxide, 0·17 iron peroxide, and 0·67 quarz.

This mineral seems a recent production from the decomposition of zinc-blende. It is found in the Rammelsberg mine near Goslar in the Harz, at Fahlun in Sweden, Schemnitz in Hungary, Holywell in Flintshire, in Cornwall, at Villefranche in France, and in great beauty near Guipuzcoa in Spain. The artificial salt is used in dyeing and medicine, and prepared either from blende or metallic zinc.

244. BIEBERITE, *Haidinger;* Sulphate of Cobalt, *Phillips;* Cobalt Sulfaté, *Dufrénoy;* Kobaltvitriol, *Mohs.*

Monoclinohedric, similar to melanterite. Usually occurs stalactitic, or as a flaky efflorescence. Colour pale rose-red. Taste astringent. Soluble in water. In closed tube yields water, and, strongly

ignited, sulphurous fumes; in other respects acts like cobalt oxide. Chem. com. $(\dot{C}o\ \dot{M}g)\ddot{S} + 7\ \dot{H}$, according to No. 2. Analyses.

	Sulph. acid.	Cobalt oxide.	Magnesia.	Watr.	Total.	
1	19·74	33·71	...	41·55	100	Kopp, Bieber near Hanau.
2	29·05	19·91	3·86	46·83	98·65	Winkelblech, Do.

Occurs in the old mines of Bieber, and also, it is said, at Leogang in Salzburg.

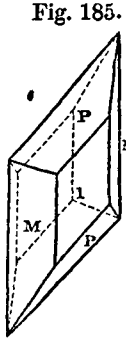
245. JOHANNITE, *Phillips;* Uran-vitriol, *John;* Hemiprismatic Euchlore-salt, *Mohs.*

Monoclinohedric, C = 85° 40′, ∞P 69°. The crystals are similar to those of trona (fig. 186), but are very small, and combined in reniform masses. Cleavage, prismatic along ∞P; H. = 2 — 2·5; G. = 3·19. Semitransparent, vitreous; colour bright grass-green, with paler streak. B.B. in closed tube yields water, becomes brown, and then acts with borax and salt of phosphorus like peroxide of uranium. According to John's researches, it is a hydrous sulphate of the protoxide of uranium. In one variety Berzelius found copper oxide. It occurs very rarely at Joachimsthal and Johann-Georgenstadt.

246. NATRON, *Beudant;* Carbonate of Soda, *Phillips;* Soda, *Hausmann;* Naturliches Mineral-Alkali, *Werner;* Soude carbonatée, *Hauy;* Hemiprismatic Natron Salt, *Mohs.*

Monoclinohedric; C = 57° 40′, usual combination of the artificial crystals (∞P∞) . ∞P . P . ∞P∞, in acute rhomboidal tables with bevelled edges (fig. 185), and ∞P (*P*) 79° 41′, P (*M*) 76° 28′. The natural salt occurs in crystalline crusts or as a pulverulent efflorescence. Cleavage, orthodiagonal distinct, and less so clinodiagonal; H. = 1 — 1·5; G. = 1·4 — 1·5. Pellucid; vitreous; colourless or greyish-white. Easily soluble in water. B.B. evolves water, and melts easily in its water of crystallization, colouring the flame yellow; fused with silica, effervesces. Chem. com. $\dot{N}a\ \ddot{C} + 10\ \dot{H}$, = 21·8 soda, 15·4 carbonic acid, and 62·8 water. In a natural natron from Debreczin in Hungary, Wackenroder found 89·84 carbonate of soda, 4·34 chloride of sodium, 1·63 sulphate of soda, 1·46 phosphate of soda, 0·03 sulphate of potassa, 0·24 carbonate of magnesia, 0·24 carbonate of lime, 0·42 siliceous peroxide of iron, 1·61 silicate of soda, and 0·15 silica (= 99·96).

Fig. 185.

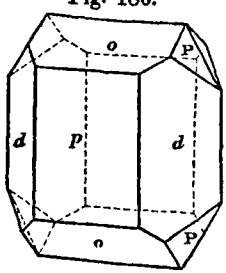


Natron seems in most cases to originate in the decomposition of various rocks or soils. It occurs on many lavas, as those of Vesuvius, Etna, and Teneriffe; and is common in the trap quarries on the Rhine with carbonate of potash, sulphate of potash, and chloride of potassium. It often forms a pulverulent efflorescence on the ground, as in the plain of Debreczin in Hungary, where about 10,000 cwts. are collected annually; and also in Bohemia, Spain, Egypt, Persia, Tartary, China, Mexico, and southern Peru. It occurs in solution in many mineral waters and salt lakes, especially those of Egypt. The purified salt is used in the manufacture of soap, and also in dyeing, bleaching, medicine, and for other purposes.

247. THERMONATRITE, *Haidinger;* Soude carbonatée prismatique, *Dufrénoy;* Prismatic Natron Salt, *Mohs.*

Rhombic; $\infty\breve{P}2 = 107° 50'$, $\breve{P}\infty = 83° 50'$; usual combination $\infty\breve{P}\infty$. $\infty\breve{P}2$. $\breve{P}\infty$, in rectangular tables with the sides bevelled (fig. 186). Cleavage, brachydiagonal perfect; H. = 1·5; G. = 1·5 — 1·6. Colourless. B.B. acts like natron, but does not melt in its water of crystallization. Chem. com. $\dot{N}a\ \ddot{C} + \dot{H}$ with 50·1 soda, 35·4 carbonic acid, and 14·5 water. Analyses, below.

Fig. 186.



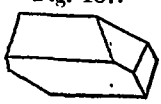
It occurs with natron at several places, and in the natron lakes at Lagunilla in Colombia, in the Macarius desert in lower Egypt, and in the Steppes between the Ural and Altai, and is deposited from their water in the warm season. According to Haidinger, a saturated solution of soda at a temperature of 77° to 99° Fahrenheit, and cooling slowly, forms crystals of thermonatrite; whereas a less saturated solution at a lower temperature forms crystals of natron. Both varieties also occur in the soda of commerce. Haidinger gives 82·26 carbonate of soda and 17·74 water as the composition of the artificial salt, but when freed from the solution it agrees with the above formula.

	Carb. acid.	Soda.	Watr.	Sulph. acid.	Sulph. of soda.	Chloride of sodium.	Earthy matter.	Total.	
1	35·1	50·2	14·7	trace	...	...	...	100	Beudant, Debreczin.
2	30·9	43·8	13·5	...	7·3	3·1	1·4	100	Do. Egypt.
3	32·3	46·7	14·0	trace	...	2·7	5·3	101	Do. Vesuvius.

248 TRONA, *Phillips, Hausmann, Dufrénoy;* Urao, *Beudant;* Prismatoidal Trona Salt, *Mohs.*

Monoclinohedric; the crystals formed predominantly by 0P and ∞P∞ (103° 15′) (fig. 187). It also forms columnar aggregates. Cleavage, orthodiagonal perfect; H. = 2·5 — 3; G. = 2·1 — 2·2. Transparent to translucent; colourless. Does not decompose in the air. Taste alkaline. B.B. like former species. Chem. com. $\dot{N}a^2\,\ddot{C}^3 + 4\,\dot{H}$ = 37·93 soda, 40·24 carbonic acid, and 21·83 water. Analyses.

Fig. 187.



	Soda.	Carb. acid.	Watr.	Sulph. of soda.	Total.	
1	37·0	38·0	22·5	2·5	100	Klaproth, Fezzan.
2	38·62	40·13	21·24	...	99·99	Beudant, Barbary.
3	41·22	39·00	18·80	...	99·02	Boussingault, Lagunilla.

The trona of the Arabs occurs at Sukena near Fezzan, and in other parts of the African desert. The Urao at Lagunilla near Mer da in Columbia.

249. GAYLUSSITE, *Boussingault, Phillips, Dufrénoy;* Hemiprismatic Kouphon Haloid, *Mohs.*

Monoclinohedric; C = 78° 27′, ∞P 68° 51′, P 110° 30′; the crystals often prismatic and lengthened along P. Occur imbedded separately in clay. Cleavage, prismatic along ∞P imperfect. Fracture conchoidal. H. = 2·5; G. = 1·9 — 1·95. Transparent; lustre vitreous; colourless. Slowly and partially soluble in water. In the closed tube decrepitates and becomes opaque. B.B. fuses readily to an opaque bead. Chem. com. $\dot{N}a\,\ddot{C} + \dot{C}a\,\ddot{C} + 5\,\dot{H}$, which agrees closely with a recent analysis by Boussingault, who found 34·5 carbonate of soda, 33·6 carbonate of lime, 30·4 water, 1·5 clay (= 100).

It occurs at Lagunilla near Merida, in a bed of clay at the natron lakes, and from the form of its crystals is named *Clavos* (nails) by the natives.

250. BORAX, *Beudant;* Tinkal, *Hausmann;* Borate of Soda, *Phillips;* Soude boratée, *Hauy;* Prismatic Borax Salt, *Mohs.*

Monoclinohedric; C = 73° 30′, ∞P 87°, P 120° nearly; usual combination ∞P . ∞P∞ . (∞P∞) . 0P . P; almost isomorphous with augite. Twin crystals are frequent, united by a face of ∞P∞. Cleavage, orthodiagonal perfect, prismatic along ∞P less distinct.

Fracture conchoidal, rather brittle. H. = 2 — 2·5; G. = 1·7 — 1·8. Pellucid; lustre resinous; colourless, but coloured yellowish, greenish, and greyish-white. Taste feebly alkaline and sweetish. In the closed tube yields much water. B.B. intumesces greatly, becomes black, and finally melts to a transparent colourless bead, colouring the flame yellow, or, when moistened with sulphuric acid, green. Soluble in 12 parts of cold water. Chem. com. of the pure salt $\dot{N}a\ddot{B}^2$ + 10 $\dot{H}$, with 16·37 soda, 36·53 boracic acid, and 47·10 water; but it often contains many impurities; and Fownes and Sullivan found in it 2·13 per cent. phosphoric acid. Hutstein states that it crystallizes from a hot solution, at temperatures from 167° to 212° Fahr., in very beautiful octahedrons with 6 atoms water; at lower temperatures in oblique rectangular prisms with 10 atoms water.

This mineral occurs in loose crystals in the clay on the shore of some alpine lakes in Thibet and Nepal, along with rock salt. Also in South America near Potosi, and it is said in Ceylon. The pure borax is prepared from this mineral, and forms the most valuable reagent for blowpipe experiments. It is also used in preparing fine glass, in medicine, and in South America as a flux in melting copper ores.

251. SASSOLINE, *Jameson, Hausmann;* Boracic acid, *Phillips;* Acide boracique, *Hauy;* Prismatic Borax Acid, *Mohs.*

Triclinohedric according to Miller; 0P : $\infty\breve{P}\infty$ = 75° 30′; usually fine scaly, or fibrous. The thin crystals or scales are irregular six-sided tables with the edges replaced by oblique planes, or 0P . ∞P′ . ∞P . $\infty\breve{P}\infty$. They occur free or combined in crusts, and stalactitic aggregates. Macles frequent, united by $\infty\breve{P}\infty$. Cleavage, basal very perfect. Sectile and flexible; H. = 1; G. = 1·4 — 1·5. Translucent; lustre pearly; generally coloured greyish or yellowish-white. Taste acidulous and slightly bitter. Feels greasy. Easily soluble in boiling, less so in cold water. In the closed tube yields water. B.B. frothes up and melts easily to a hard, transparent glass, colouring the flame green. The solution in alcohol burns with a green flame. Chem. com. $\ddot{B}$ + 3 $\dot{H}$, with 56·3 boracic acid and 43·7 water. Klaproth found in the variety from Tuscany 81·33 hydrous boracic acid, 10·50 sulphate of manganese protoxide, 2·83 sulphate of lime, 0·33 iron peroxide, 0·66 alumina, 2·66 silica, and 1·66 carbonate of lime (= 99·97). In a specimen from the same country Wittstein finds 76·50 hydrous boracic acid, 6·56 water, 1·02 silica, 0·32 alumina, 0·29 chloride of ammonium, 1·32 sulphuric acid, with these sulphates, 8·50 of ammonia, 2·63 of magnesia, 0·91 of soda, 0·37 of potash, and 0·36 of iron peroxide (= 99·79). In the variety from Vulcano, Stro-

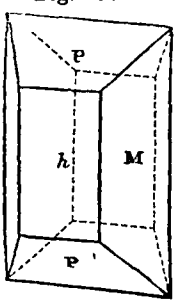
meyer found only a minute amount of sulphuric acid; and Erdmann ammonia, in one case to 3·18 per cent.

It occurs on Vulcano in the Lipari islands, in the hot springs of Sasso near Sienna, and in the lagoni of Tuscany, from which, in 1845, about 2,000,000 lbs. avoirdupois were procured by evaporating the water. Also in the Andes of Atacamain South America.

252. NITRE, *Jameson;* Salpeter, *Werner;* Kalisalpeter, *Hausmann;* Nitrate of Potash, *Phillips;* Potasse Nitratée, *Hauy;* Prismatic Nitre Salt, *Mohs.*

Rhombic; ∞P (*M*) 119°, $2\breve{P}\infty$ (*P*) 71°, $\breve{P}\infty$ (*x*) 110°, usual combination ∞P . $\infty\breve{P}\infty$ (*h*) . $2\breve{P}\infty$, the crystals (fig. 188) prismatic.

Fig. 188.



Macles united by a face of ∞P. All the forms are isomorphous with those of arragonite. Naturally it only occurs in acicular or capillary crystals, as a flaky or pulverulent coating, or in fine granular crusts. Cleavage, brachydiagonal and prismatic along ∞P indistinct. Fracture conchoidal; H. = 2; G. = 1·9 — 2. Semitransparent; vitreous, or silky when fibrous; colourless, white or grey. Taste saline and cooling. Easily soluble in water. Deflagrates when placed on hot charcoal; and B.B. on platina wire melts very easily, colouring the flame violet. Chem. com. of the pure salt $\dot{K}\ddot{N}$ with 46·6 potash and 53·4 nitric acid. The natural salt is always more or less mixed with other substances, and, in a variety from Molfetta in Apulia, Klaproth found 42·75 nitrate of potash, 25·50 sulphate of lime, 0·20 chloride of potassium, and 30·20 limestone (= 98·85). It occurs there as an efflorescence from limestone in the so-called salpetre caves.

Similar caves are found near Homburg, as Burkhard's cave, in the limestone rocks of Kentucky, in Brazil west of Tejuco, and in Ceylon. Nitre is also found in considerable amount in Hungary, Podolia, the Ukraine, in Spain, Italy, France, near Mount Sinai in Arabia, in Egypt, Persia, and near Agra in Bengal. In Malta it is formed by the action of the sea water on limestone. It is used for producing nitric acid, in glass-making, medicine, and more especially in the manufacture of gunpowder.

253. NITRATINE, *Haidinger;* Natronsalpeter, *Naumann;* Nitrate of Soda, *Phillips;* Soude nitratée, *Hauy;* Rhombohedral Nitre-salt, *Mohs.*

Rhombohedric; R = 106° 30′, isomorphous with dolomite. Occurs in crystals of the primary form, and in crystalline grains. Cleavage

along R rather perfect. H. = 1·5 — 2; G. = 2·1 — 2·2. Translucent or transparent, with very distinct double refraction. Lustre vitreous; colourless, or greyish and yellowish-white. Taste saline and cooling. Easily soluble in water. Deflagrates on hot charcoal, but less violently than nitre. B.B. fuses on platina wire, colouring the flame yellow. Chem com. of pure salt $\dot{N}a\,\ddot{N}$, with 36·6 soda and 63·4 nitric acid. The native salt is generally mixed with common salt and other substances. Analyses.

	Nitrate of soda.	Chloride of sodium.	Sulph. of soda.	Iodide of sodium.	Watr.	Mixtures.	Total.	
1	96·70	1·30	...	...	2·00	...*a*	100	Le Canu, Atacama desert.
2	64·98	28·69	3·00	0·63	...	2·60*b*	99·90	Hayes, Tarapaca.
3	64·00	29·30	2·25	...*c*	...	0·50*b*	98·80	Blake, Do.
4	70·20	20·70	5·65	2·20	...	1·05*b*	99·80	Do. Do.
5	94·29	1·99	...	...	1·99	0·20*d*	100	Hofstetter, Do.

(*a*) With traces of sulphates of alkalis and lime; (*b*) shells and marl; (*c*) + 2·75 sulphate of magnesia; (*d*) sand, + 0·24 sulphate of potash, 0·43 nitrate of potash, and 0·86 nitrate of magnesia.

This salt occurs in the district of Tarapaca on the northern frontier of Chili, where it forms beds averaging four feet thick, and extending forty leagues in length. It rests on marl containing fragments of shells in a basin-like pampa, and is mixed with various other salts. It has been supposed left by the sea, but the chemical nature of the salt is against this opinion. In 1837, 150,000 quintals of the refined nitratine were shipped from Yquique. It is used in the arts as a substitute for nitre; but is unfit for manufacturing gunpowder from its deliquescing in the air.

254. NITROCALCITE, *Shepard;* Nitrate of Lime, *Phillips;* Kalksaltpeter, *Hausmann;* Chaux nitratée, *Hauy.*

Occurs in fibrous or pulverulent efflorescences, of a white or grey colour. Translucent. Taste sharp and bitter. Readily soluble in water, and deliquesces in the air. Melts slowly on burning charcoal with slight detonation. Chem. com. $\dot{C}a\,\ddot{N} + \dot{H}$, or, by Shepard's analysis, 32·00 lime, 57·54 nitric acid, and 10·56 water (= 100). The specimen was from the limestone caves of Kentucky, where it is very abundant. It is frequent on old walls and limestone rocks, especially near decaying animal matter.

255. NITROMAGNESITE, *Shepard;* Nitrate of Magnesia, *Phillips;* Magnésie nitratée, *Dufrénoy;* Magnesiasalpeter, *Naumann.*

Occurs in the same places with nitrocalcite, with which it agrees in

colour and other characters. Taste bitter. Chem. com. probably $\dot{M}g\ \dot{N} + \dot{H} = 24$ magnesia, 65 nitric acid, and 11 water.

256. SAL-AMMONIAC, *Jameson;* Muriate of Ammonia, *Phillips;* Salmiak, *Werner;* Ammoniaque muriatée, *Hauy;* Octahedral Ammoniac-salt, *Mohs.*

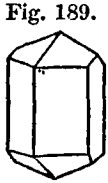
Tesseral; O, also combinations with $\infty O\infty$, ∞O, and $2\dot{O}2$. Occurs in crusts, stalactites, and earthy or pulverulent masses. Cleavage, octahedral imperfect; fracture conchoidal. H. = 1·5 — 2; G. = 1·5 — 1·6. Pellucid; vitreous; colourless, but inclining to grey or yellow, sometimes to green, brown, or black. Taste saline and pungent. Easily soluble in water. B.B. volatilizes without fusing. With soda on platina wire gives out a strong smell of ammonia; and on copper wire colours the flame bluish-green. Chem. com. of the pure salt, muriate of ammonia = $N\ H^3 + H\ Cl$, with 32 per cent. ammonia; or chloride of ammonium = $N\ H^4\ Cl$, with 33·9 ammonium and 66·1 chlorine. In a white crystallized specimen from Vesuvius, Klaproth found only 0·5 per cent. of chloride of sodium; and in a greyish-white massive sal-ammoniac from Tartary, 2·5 per cent. sulphate of ammonia. The yellow variety is coloured by chloride of iron or sulphur, with which it is often associated.

This mineral chiefly occurs as a sublimate in cracks and fissures near active volcanos. It was found in great abundance in the crater of Vesuvius during the eruption of 1822; and is common on Etna, the Solfatara near Naples, the island Vulcano, and Iceland. It is also brought from Bucharia in Tartary. It is sometimes found near ignited coal seams, as at St Etienne in France, near Newcastle, and in Scotland. It is used in medicine, dyeing, and various metallurgic operations, but chiefly prepared by chemical processes.

257. MASCAGNINE, *Reuss, Hausmann;* Sulphate of Ammonia, *Phillips;* Ammoniaque sulfaté, *Hauy;* Prismatic Ammoniac Salt, *Mohs.*

Rhombic, ∞P 107° 40′, $\breve{P}\infty$ 121° 16′; usual combinations $\infty P . \infty\breve{P}\infty . P$ (fig. 189); but chiefly in crusts and stalactites. Cleavage, brachydiagonal rather perfect; sectile; H. = 2 — 2·5; G. = 1·7 — 1·8. Pellucid, vitreous; colourless, white or yellowish; taste pungent and bitter; easily soluble in water, and attracts moisture from the atmosphere. B. B. when heated decrepitates, then melts, and at length wholly volatilizes. Chem. com. of the artificial salt $N\ H^3\ \dot{S} + \dot{H}$, with 25·9 ammonia, 60·5 sulphuric acid, and 13·6 water; Berzelius gives 2 atoms or 23·9 per cent. water,

Fig. 189.



with 22·8 ammonia and 53·3 sulphuric acid. Occurs, but rarer than sal-ammoniac, in fissures near volcanos, as on Etna, Vesuvius, the Solfatara, the Lipari Islands, and in the lagoni near Sienna in Tuscany. It also forms in ignited coal beds, as at Bradley in Staffordshire, with sal-ammoniac.

258. ARCANITE, *Haidinger;* Sulphate of Potash, *Phillips;* Kali-sulphat, *Naumann;* Potasse sulfatée, *Hauy;* Aphthalose, *Beudant;* Prismatic Pycrochylin-Salt, *Mohs.*

Rhombic in rather acute pyramids, with ∞P 120° 24′, 2P̆∞ 67° 38′, 0P, and other forms. Mostly in crusts or pulverulent coatings. Cleavage, basal imperfect; H. = 2·5 — 3; G. = 1·73. Pellucid; vitreous or resinous; colourless or white, inclining to yellow, externally greenish or bluish; taste saline, bitter; soluble in water. B.B. decrepitates, fuses, and on cooling crystallizes (becomes hepatic, *Rammelsberg*). The solution is precipitated by acetic acid. Chem. com. K̇ S̈, with 54·04 potash and 45·96 sulphuric acid. It is rather rare, but occurs in the lavas of Vesuvius and other volcanos, and in solution in the water of some salt springs.

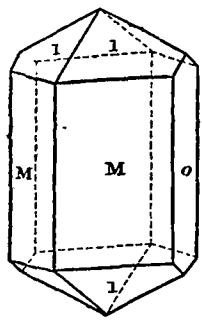
259. THENARDITE, *Casaseca, Phillips, Dufrénoy, Mohs.*

Rhombic, in rather acute pyramids P, with 0P and ∞P, combined in crusts and druses. Surface rough, and with little lustre. Cleavage, basal rather perfect; fracture uneven; H. = 2·5; G. = 2·6 — 2·7. Pellucid, vitreous, white; taste feebly saline; easily soluble in water, and acquires a white crust by attracting moisture from the air. B.B. colours the flame deep-yellow, fuses, and on charcoal is reduced to sulphuret of sodium. Chem. com. Ṅa S̈ with 43·82 soda and 56·18 sulphuric acid. Casaseca found 99·78 sulphate of soda and 0·22 carbonate of soda in a specimen from Salinas d'Espartinas near Aranjuez, five leagues from Madrid, where it is deposited by the water of the salt springs during the summer months. It is used for preparing soda.

260. EPSOMITE, *Beudant;* Epsom-salt, *Jameson;* Sulphate of Magnesia, *Phillips;* Bittersalz, *Werner;* Magnésie sulfatée, *Hauy;* Prismatic Bitter-salt, *Mohs.*

Rhombic; the pyramid P mostly hemihedric, and formed as a rhombic sphenoid, ∞P 90° 38′. Usual combinations ∞P . P, and ∞P (*M*) . ∞P̆∞ (*o*) . P (*l*), in prismatic crystals (fig. 190). The natural

Fig. 190.



salt forms granular, fibrous, or earthy aggregates or efflorescences. Cleavage, brachydiagonal perfect; H. = 2 — 2·5; G. = 1·7 — 1·8. Pellucid, vitreous, and colourless or white, sometimes pale rose-red; taste saline, bitter; easily soluble in water. In the closed tube it yields much water with no acid reaction, fuses and continues unchanged. B.B. on charcoal again fuses, loses its acid, incandesces, and shows alcaline reaction. With solution of cobalt becomes pale rose-red. Chem. com. $\dot{M}g\ddot{S} + 7\dot{H}$, with 16·32 magnesia, 32·53 sulphuric acid, and 51·15 water. Analyses.

	Magnesia.	Sulph. acid.	Watr.	Mang. perox.	Iron prot.	Total.	
1	14·58	32·26	49·24	3·62	...	99·70	Stromeyer, Bosjesman River.
2	16·39	32·30	50·93	...	0·23	99·85	Do. Idria (hair-salt).
3	16·50	31·90	51·20	...	...	99·60	Do. Calatayud, Arragon.
4	15·31	31·37	51·70	0·34	0·09*a*	99·83	Do. Neusohl, Hungary (red).
5	17·31	34·37	48·32	...	...	100	Bouis, Fitou, France.
6	16·20	34·07	47·20	...	.. *b*	99·57	Dufrénoy, Do.
7	15·97	32·46	50·60	...	... *c*	99·86	Osersky, Caucasus.

(*a*) + 0·69 cobalt protoxide, and 0·38 copper protoxide; (*b*) + 2·10 lime; (*c*) + 0·47 soda and 0·36 mixtures.

This salt forms as an efflorescence on various rocks containing magnesia and iron pyrites. It thus occurs in the old coal wastes or alum mines at Hurlet near Paisley, in the quicksilver mines of Idria, in the gypsum of Montmartre, at Freiberg, and other places. At Neusohl in Hungary it occurs stalactitic (No. 4), and contains water in small cavities, which renders it moist when rubbed. It effloresces from the ground in many parts of Spain, and in great abundance in the Russian Steppes. It is contained in many mineral waters; and much of that used in commerce is obtained from these, as at Epsom in Surrey (Epsom salts), Sidschütz and Seidlitz in Bohemia, and other places. It is chiefly used in medicine and in preparing magnesia. According to Haidinger and Mitscherlich, the crystals of epsomite formed at a temperature below 60° Fahr. are rhombic; whilst those crystallizing between 77° and 87° are clinohedric.

The *Astrakanite* of Rose occurs in white, transparent, prismatic crystals among the salts in the salt lakes east of the mouth of the Wolga. Its composition is $\dot{M}g\ddot{S} + \dot{N}a\ddot{S} + 4\dot{H}$, or, by G. Rose's analysis, 41·00 sulphate of soda, 35·18 sulphate of magnesia, 21·56 water, 0·33 chloride of magnesium, and 1·75 gypsum and sand.

The *Reussin* of Karsten, in white, six-sided, and pointed crystals forming radiating groups, from Seidlitz and Saidschütz in Bohemia, is similar. Reuss found 66·04 sulphate of soda, 31·35 sulphate of magnesia, 2·19 chloride of calcium, and 0·42 sulphate of lime. It seems, however, only a mixture of these salts.

III. ORDER.—SALINE ORES.

I. Family.—The Sparry Iron Ores.

261. Siderite, *Haidinger;* Sparry Iron, *Jameson;* Spathose Iron, Carbonate of Iron, Brown-spar, *Phillips;* Spatheisenstein, *Werner;* Sphärosiderite, *Hausmann;* Fer carbonaté, *Dufrénoy;* Brachytypous Parachrose Baryte, *Mohs.*

Rhombohedric; R 107°. In the crystals R chiefly predominates, occasionally with 0R, $-\frac{1}{2}$R, ∞R, -2R, ∞P2. The rhombohedrons are often curved, saddle-shaped, or lenticular. It frequently occurs massive, in fine or coarse granular aggregates, more rarely in small botryoidal or reniform shapes (Sphærosiderite); also mixed with clay in compact or fine granular masses. Cleavage, rhombohedral along R perfect; H. = 3·5 — 4·5; G. = 3·7 — 3·9. Translucent in various degrees, becoming opaque when weathered. Lustre vitreous or pearly; colour rarely white, generally yellowish-grey or yellowish-brown, changing to red or blackish-brown on exposure, when it is converted into the hydrated peroxide. B.B. infusible, but becomes black and magnetic. With borax and salt of phosphorus shows reaction for iron; with soda usually for manganese. In acids soluble with effervescence. Chem. com. $\dot{F}e\,\dot{C}$ or carbonate of iron, with 62·6 iron protoxide and 37·9 carbonic acid, but part of the protoxide of iron usually replaced by protoxide of manganese, by magnesia, or lime. Analyses, next page.

These analyses, to which many might be added, show the variations in composition of this important mineral. None of them are pure carbonate of iron, which seems never to occur alone, but always mixed with the protoxide of manganese (Nos. 7–13), or with magnesia (Nos. 14, 15). The purest is the fibrous variety (Nos. 1, 2) from Steinheim near Hanau, where it occurs in spheroidal masses in the

	Iron protox	Mang. protox	Lime.	Magnesia.	Carb. acid.	Vein-stone, &c.	Total.	
1	63·75	0·75	...	0·25	34·0	...	98·75	Klaproth, Steinheim, Hanau.
2	59·63	1·89	0·20	...	39·04	...	99·91	Stromeyer, Do. Do.
3	53·0	0·6	...	5·4	41·0	...	100	Berthier, Baigorry, France.
4	53·0	0·8	1·0	4·5	38·7	2·0	100	Do. Pacho, St Fe de Bogota.
5	63·25	3·00	1·00	...	30·00	...*a*	99·00	Hisinger, Riddarhyttan.
6	57·91	1·51	0·50	trace	36·61	0·60*b*	99·12	Karsten, Babkowsky, U. Silesia.
7	83·5	6·5	...	0·7	39·2	...	99·9	Berthier, Rancié, Pyrenees.
8	46·3	9·1	...	4·5	38·4	1·4	99·7	Do. Bendorff, Coblentz.
9	43·0	11·0	...	2·3	38·0	5·7	100	Do. Allevard, Isère.
10	50·41	7·51	...	2·35	38·64	0·32	99·23	Karsten, Hachenburg.
11	47·20	8·34	0·63	3·75	39·85	0·95	99·72	Do. Siegen.
12	36·91	25·31	...	...	38·35	...	100·47	Magnus, Ehrenfriedersdorf.
13	43·59	17·67	0·48	0·24	38·22	...	100	Schnabel, Eisen, Siegen.
14	45·2	0·6	...	12·2	40·4	...	98·4	Berthier, Autun, France.
15	42·8	...	...	15·4	41·8	...	100	Do. Allevard, Isère.
16	53·6	...	...	3·7	33·5	8·1*d*	98·9	Dufrénoy, Poullaouen.
17	43·26	trace	1·89	...	30·30*e*	20·78*e*	96·23	Phillips, Yorkshire.
18	49·38	...	1·54	...	32·48	13·10*f*	100	Dufrénoy, Dudley.
19	45·84	0·20	1·90	5·90	33·63	7·83*g*	100·68	Colquhoun, Crossbasket, Glasgow.
20	47·33	0·13	2·00	2·20	33·10	6·63*h*	100·20	Do. Clyde Iron works.

(*a*) + 1·75 water; (*b*) + 1·92 carbon; (*c*) with water: (*d*) silica; (*e*) silica and alumina; (*f*) do. + 3·50 bitumen, water, and loss; (*g*) silica + 2·53 alumina, 1·86 carbon and bitumen, and 0·99 water; (*h*) silica, + 4·30 alumina, 1·70 carbon and bitumen, 0·33 iron peroxide, 0·22 sulphur, and 2·26 water and loss.

fine-grained greenstone or anamesite; of which rock it also forms a constituent. Hausmann has remarked the strong tendency of the siderite to assume a spherical form, as manifested in the curved faces of its rhombohedrons, and in the similar form which the carbonates of lime or magnesia, when mixed with a small proportion of the carbonate of iron and manganese protoxide, often assume. This does not destroy its crystalline tendency, and the two structures are found combined. It is also curious that, whilst a small portion of clay destroys the tendency to crystallize, both in this mineral and in calc-spar, a much larger proportion of quartz does not interfere with it. Breithaupt has distinguished the varieties with more than 20 per cent. manganese protoxide (No. 12) as *Oligon-spar*.

The siderite occurs in beds or masses, often of immense extent, especially in Styria and Carinthia. In the Erzberg near Eisenerz in Styria, it rests on gneiss, and is wrought as an open quarry. The Stahlberg and Momel near Schmalkald, the vicinity of Siegen, and Musen in Westphalia, show similar extensive masses; whilst in Anhalt and the Harz it forms large veins in greywacke, or Devonian limestone. Other very extensive deposits of this ore are found in the Pyrenees and the Basque provinces of Spain, as near Bilboa; and at Pacho near Bogota in New Granada. Most of these localities yield fine crystals; and these also occur in metallic veins at Joachims-

thal in Bohemia, Freiberg in Saxony, Klausthal in the Harz, Beeralstone in Devonshire, Alston Moor in Cumberland, and in many of the tin mines of Cornwall, particularly the rare hexagonal prisms.

The clay ironstone, of grey, blue, brown, or black colours, with G. = 2·8 — 3·5; H. 3·5 — 4·5, is an impure variety of this mineral. It occurs chiefly in slate-clay or marls, in layers or nodular masses, often containing fossil plants or other organic bodies, which seem to have attracted the carbonate of iron. In these nodules, crystals of siderite, calc-spar, celestine, barytes, quarz, pyrites, blende and galena, often occur. This variety is found occasionally in the transition rocks, but especially in the coal formation of Britain, Belgium, and Silesia, in vast abundance. It is more rare in the oolite and chalk in Northern Germany and England; and in the brown coal of Radnitz in Bohemia, and other places, frequently forms petrifactions of wood. Nos. 17–20 above are varieties, and the following is the composition of the celebrated black-band Nos. 1–5, and other argillaceous iron ores of Scotland and Wales (vide Mem. of Geol. Survey, vol. i. pp. 186, 187).

	Carbonate of iron.	Carbonaceous matter.	Earthy matter.	Metallic iron in carbon.	
1	70·0	23·0	7·0*a*	33·7	Black Band, Lanarkshire.
2	51·04	22·16	26·80	24·6	Cwan Avon bed, S. Wales.
3	63·9	10·0	26·1	30·7	Maesteg valley, Upper bed, Up. Div.
4	79·9	6·6	13·5	38·5	Do. Do. Lower Division.
5	79·5	16·4	4·1	38·4	Beaufort, Pontypool, 4-inch band.
6	86·0	...	14·0	41·5	Ystradgunlas, Upper vein.
7	72·4	...	27·6	34·9	Ib. another bed.
8	75·4	...	24·6	36·4	Pendaren, Red vein.
9	60·9	...	39·1	29·4	Aberfergwm, nodules.
10	55·5	...	44·5	26·6	Pendaren, Jack vein.

(*a*) Includes silica, alumina, and trace of lime.

The pure variety of this mineral is the ore used in forming the Styrian steel, and also in the French Pyrenees and northern Spain It is either allowed partially to decompose by exposure to the air, or is roasted, and then converted at once into bar iron or steel. From the clay iron-stone or impure varieties, again, most of the British iron is manufactured; the carbonaceous matter in the black-band varieties aiding materially in their reduction. The amount of iron produced in Great Britain annually has been estimated at from 1½ to 2 million tons, worth about nine millions sterling. In 1846, South Wales alone produced about half a million tons, and Scotland considerably above that quantity.

The *Junkerite* of Dufrénoy (No. 10 of table, p. 340), which occurs at Poullaouen in Brittany in small quartz veins in greywacke, is a mere variety of siderite, with which, as Breithaupt has shown, it agrees in crystalline form.

262. ANKERITE, *Haidinger*, *Phillips;* Dolomie, *Dufrénoy*, in part; Paratomous Lime-Haloid, *Mohs.*

Rhombohedric, R 106° 12′, mostly massive and granular. Cleavage, along R perfect, the cleavage planes often curved; H. = 3·5—4; G. = 2·95 — 3·1. Translucent or only on the edges; vitreous, inclining to pearly; colour yellowish-white or grey, becoming brown when weathered. B. B. becomes black and magnetic; with soda shows reaction for manganese; soluble with effervescence in nitric acid, the solution gives traces of lime and magnesia. Chem. com. carbonates of lime, magnesia, iron protoxide, and manganese protoxide in variable proportions. Analyses.

	Carbonate of lime.	Carbonate of magnes.	Carbon. of iron protox.	Carb. of manga. protox.	Total.	
1	50·11	11·85	35·31	3·08	100·35	Schrötter, Hohe Wand, Styria.
2	51·1	25·7	20·0	3·0	99·8	Berthier, Gollrath, Styria.
3	50·9	29·0	18·7	0·5	99·1	Do. Corniglion, Vizille.
4	50·5	32·4	12·3	...*a*	99·5	Do. Mühlen Graubundten.

(*a*) + 4·3 veinstone and water.

This mineral occurs at Rathhausberg in the Valley of Gastein in Salzburg, in beds in mica slate; and more especially in connection with siderite in Styria, as at Golrath, Eisenerz, and the Nieder Alp. Other varieties are found in the limestone mountains at Raiding near Vordernberg, on the Rothsol, the Veitsch Alp, and other places. It is valued by the Styrian miners as an ore of iron or flux, and named Rohwand, Rosszahn, and Wandstein.

This mineral seems to pass on the one hand into breunnerite; and on the other, into siderite, by the gradual substitution of isomorphous elements. Nos. 3 and 4 are rather breunnerites, or transition varieties; and No. 15 of dolomite, p. 291 above, a similar variety connecting this species with dolomite. The variety from the Erzberg in Styria, in which Sanders found 49·61 iron protoxide, 6·67 lime, 5·18 magnesia, 0·10 manganese protoxide, and 38·44 carbonic acid (= 100), may indeed be considered a true siderite.

263. DIALLOGITE, *Beudant;* Manganese-spar; Red Manganese, *Allan;* Carbonate of Manganese, *Phillips;* Rother Braunstein Manganspath, *Werner;* Manganèse carbonaté, *Hauy;* Macrotype Parachrose Baryte, *Mohs.*

Rhombohedric; R 106° 51′ (*Mohs*), to 107° (*Breithaupt*). The more common forms are R and $-\frac{1}{2}$R, sometimes with 0R and ∞P2; other forms are rare. The crystals are often curved lenticular or saddle-shaped, and generally united in druses. It also forms spherical, reniform, and columnar aggregates, or granular masses. Cleavage,

rhombohedric along R, perfect; H. = 3·5 — 4·5; G. = 3·3 — 3·6. Translucent; vitreous or pearly lustre; colour rose-red to flesh-red; streak white. B.B. usually decrepitates, and becomes greenish-grey or black, but is infusible. With fluxes shows reaction for manganese. The powder is slowly soluble in cold, quickly and with effervescence in warm hydrochloric acid. Chem. com. $Mn\,\dot{C}$ with 62 manganese protoxide and 38 carbonic acid, but usually mixed with carbonates of lime, magnesia, or iron. Analyses.

	Carb. of Mang. prot.	Carb. of iron prot.	Carb. of Lime.	Carb. of Magnesia.	Water.	Total.	
1	82·2	7·3	8·9	1·6	...	100	Berthier, Freiberg.
2	73·70	5·75	13·08	7·26	0·05	99·84	Stromeyer, Do.
3	90·5	...	9·5	...	...	100	Berthier, Kapnik.
4	89·91	...	6·05	3·30	0·44	99·70	Stromeyer, Do.
5	86·64	...	10·58	2·43	0·31	99·96	Do. Nagyag.
6	81·42	3·10	10·31	4·28	0·33	99·44	Kersten, Voightsberg, G. 3·553.
7	74·55	15·01	trace	...	10·11*a*	100	Kane, Glendree.
8	79·94	11·04	2·43	...	6·22*a*	100	Do. Do.

(*a*) With organic matter, &c. + 0·33 (in No. 7), and 0·37 (in No. 8), sand and clay.

This mineral occurs in veins in gneiss and porphyry with ores of silver, galena, fahlore, and blende, at Freiberg, Schemnitz, Kapnik, and Nagyag; with red hæmatite at Elbingerode in the Harz and Gonzen near Sargans in Switzerland. At the latter a hydrated variety, fibrous, silky, and yellowish or reddish, occurs, and has been named *Wiserite*. A compact diallogite is found in a tertiary deposit with manganite in Reinhardswald in Hessia. Nos. 7, 8 are analyses of a compact yellowish-grey variety, which forms a layer two inches thick below a bog at Glendree in county Clare, Ireland. Lampadius analyzed a compact diallogite from Kapnik.

Mohs distinguished some crystals from Kapnik (R = 107°), but on insufficient grounds. The *Manganhalk* of Hisinger from Langbanshytta in Sweden contains, according to Beudant, 41·43 carbonic acid, 35·77 lime, and 22·80 protoxide of manganese.

264. MANGANOCALCITE, *Breithaupt.*

According to Breithaupt, this mineral forms rhombic crystals exactly like those of arragonite, and therefore bears the same relation to diallogite that arragonite does to calc-spar. Rammelsberg found in it 67·48 carbonate of manganese protoxide, 18·81 carbonate of lime, 9·97 carbonate of magnesia, and 3·22 carbonate of iron protoxide (= 99·48). It occurs at Schemnitz.

265. LANTHANITE, *Haidinger;* Carbonate of Cerium, *Phillips, Dana;* Cerium carbonaté, *Dufrénoy.*

Tetragonal; in small tabular crystals. Usually fine granular or earthy. Cleavage basal; H. = 2·5 — 3. Lustre dull or pearly; colour white or yellowish. B.B. becomes brownish-yellow. Soluble in acids with effervescence. Chem. com. $\dot{La}^3\ \ddot{C} + 3\ \dot{H}$ according to Hermann. Hisinger's analysis, corrected by Mosander, who showed that it contained lanthanium, and not cerium, gave 10·8 carbonic acid, 75·7 lanthanium oxide with traces of cerium oxide, and 13·5 water (= 100).

It occurs at Bastnæs near Riddarhyttan in Sweden.

266. PARISITE, *Bunsen.*

Hexagonal, P 164° 58′; occurs crystallized in the primary form. Cleavage, basal very perfect. H. = 4·5; G. = 4·35. Vitreous, on the cleavage planes pearly. Colour brownish-yellow inclining to red. In the closed tube yields water and carbonic acid, and becomes brown. B.B. infusible, and phosphoresces; with borax forms a yellow glass, becoming colourless when cold. Chem. com. $8(\dot{Ce}, \dot{Ca})\ \ddot{C} + 2\ Ca\ F + \dot{Ce}\ \dot{H}$; or, by Bunsen's analysis, 23·51 carbonic acid, 59·44 protoxide of cerium, with protoxides of lanthanium and didymium, 3·17 lime, 11·51 fluoride of calcium, and 2·38 water. It is found in the emerald mines of the Musso Valley in New Granada.

267. CALAMINE, *Jameson;* Smithsonite, *Beudant;* Carbonate of Zinc, *Phillips;* Galmei, *Werner;* Zinkspath, *Naumann;* Zinc carbonaté, *Hauy;* Rhombohedral Zinc-baryte, *Mohs.*

Rhombohedric, R 107° 40′; the more common forms are R, 4 R̆, and R^3; 0R, $-\frac{1}{2}R$, $-2R$, and $\infty P2$, are also known. The crystals generally small or very small, obtuse-edged, and apparently rounded. Usually it occurs in reniform, botryoidal, stalactitic, and laminar aggregates, or fine granular and almost compact. Cleavage, rhombohedric along R perfect, the planes sometimes curved. Fracture uneven conchoidal. Brittle. H. = 5·0; G. = 4·1 — 4·5 (4·442 a yellow crystal). Translucent or opaque; lustre pearly or vitreous; colourless, but often coloured pale greyish-yellow, brown, or green. B.B. becomes white, loses its carbonic acid, and acts like zinc oxide. It sometimes forms in the reducing flame a dark-yellow or red ring on the charcoal from cadmium oxide. Soluble in acids with effervescence; also in solution of potash. Chem. com. $\dot{Zn}\ \ddot{C}$, with 64·5 zinc oxide and 35·5 carbonate of lime, but seldom pure. Analyses, next page.

	Carbonate of						Silicate of zinc.	Total.	
	Zinc oxide.	Iron prot.	Mang. prot.	Lime.	Magnesia.	Lead oxide.			
1	96·00	2·03	...	...	...	1·12	...	99·15	v. Kobell, Nertschinsk.
2	60·35	32·21	4·02	1·90	0·14	...	2·49	101·11	Monheim, Altenberg, G. 4·15.
3	55·89	36·46	3·47	2·27	...	...	0·41	98·50	Do. Do. G. 4·04.
4	84·92	1·58	6·80	1·58	2·84	...	1·85	99·57	Do. Do. G. 4·20.

Smithson, in a variety from Somersetshire, found 64·8 oxide of zinc and 35·2 carbonic acid; in another from Derbyshire, 65·2 oxide of zinc and 34·8 carbonic acid. Berthier analyzed many varieties in which the carbonate of zinc varied from 30 to 90 per cent., the other components being carbonates of iron, manganese, lead, and lime.

This mineral occurs in beds or veins in the crystalline and transition rocks, and also in the carboniferous and oolite formations. It is most common in limestone, and is often associated with calc-spar, quartz, blende, and ores of iron and lead. Chessy near Lyons, the Altenberg near Aix-la-Chapelle, Brillon in Westphalia, Tarnowitz in Silesia, Carinthia, Hungary, Siberia, Jefferson county in Missouri N. America, are a few of its foreign localities. Mendip in Somersetshire, Matlock in Derbyshire, Wanlockhead and Lead Hills in Scotland, also yield this mineral. A compact, fibrous, pale-yellow variety occurs at Alston Moor.

The zinc is obtained from this mineral chiefly by distillation, and it was formerly used for manufacturing brass. In Silesia cadmium is also obtained from it.

The *Kapnite* of Breithaupt includes the varieties with more than 15 per cent. of iron protoxide. They have often a brownish-yellow colour, lower specific gravity than the others, and more resemblance to siderite.

The *Zinc-bloom* (*Zinkblüthe*), distinguished from calamine by Smithson, seems a mere produce of its decomposition. It occurs in reniform earthy masses, of a pale-yellow colour, and shining streak. A specimen from Bleiberg contained 71·4 zinc oxide, 13·5 carbonic acid, and 15·1 water (*Smithson*); corresponding to $\dot{Zn}^3\,\ddot{C} + 3\,\dot{H}$, or, as Rammelsberg thinks, a hydrous carbonate of zinc mixed with hydrate of zinc oxide. It yields water in the closed tube, but otherwise agrees with calamine. It is found at Bleiberg and Raibel in Carinthia.

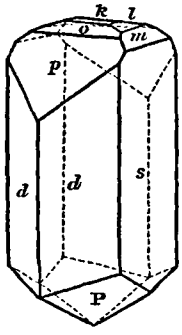
The *Herrerite* of Del Rio, from Albarradon in Mexico, is said to be rhombohedric, but is only found massive, with curved cleavage planes. H. = 4 — 5; G. = 4·3. Translucent; pearly or vitreous; and pistacio, emerald, or grass-green. B.B. on charcoal becomes grey, fumes, and stains the charcoal white. In the closed tube it yields white fumes, condensing in transparent drops. It consists,

according to Del Rio, of carbonates of zinc oxide and nickel oxide; according to Herrera, of tellurium, with carbonate of nickel oxide; but is probably a mere mixture.

268. GALMEI, *Werner;* Electric Calamine, *Jameson;* Siliceous oxide of Zinc, *Phillips;* Zinksilicat, *Naumann;* Zinc oxidé silicifère, *Hauy;* Prismatic Zinc-Baryte, *Mohs.*

Rhombic, and hemimorphic; P (*P*) with polar edges 101° 9′ and 132° 9′; $\infty\breve{P}2$ (*d*) 103° 53′, $\breve{P}\infty$ (*o*) 116° 40′, $\frac{1}{2}\bar{P}\infty$ (*l*) 128° 26′. The more common combinations are $\infty\bar{P}\infty$ (*s*) . $\infty\bar{P}2$. $\frac{1}{2}\bar{P}\infty$, and $\infty\bar{P}\infty$. $\infty\breve{P}2$. $\breve{P}\infty$ (fig. 191). The crystals are small, and either long and tabular, or short and broad prismatic They are frequently bounded at the lower end by the pyramid P. They occur attached and in drusses, or combined in diverging spheroidal or reniform groups. It also occurs in fine columnar and fibrous aggregates of similar forms, or granular, compact, and earthy. Cleavage, prismatic along $\infty\breve{P}2$ very perfect, brachydomatic along $\breve{P}\infty$ perfect. H. = 5; G. = 3·3 — 3·5. Transparent to translucent; lustre vitreous, and on $\infty\bar{P}\infty$ pearly; colourless or white, but often various light tints of grey, and also of yellow, green, brown, and blue; becomes electric by heat, the upper end of the crystal in the figure being the analogue, the lower the antilogue pole. Where two such crystals are united in the direction of their axes, the analogue poles are at the ends, the antilogue in the middle.

Fig. 191.



In the closed tube it yields water. B.B. decrepitates slightly, but is infusible, or melts with great difficulty only on the edges. With solution of cobalt becomes blue on the fused edges, otherwise green. Readily soluble in acids, when the silica gelatinizes. Chem. com. $3\,\dot{Z}n^2\,\ddot{S}i + 4\,\dot{H}$, with 25·1 silica, 65·2 zinc oxide, and 9·7 water; but No. 7 gives the simpler formula $\dot{Z}n^2\,\ddot{S}i + \dot{H}$, with 25·7 silica, 66·8 zinc oxide, and 7·5 water. Analyses, next page.

Occurs with calamine in most localities, especially at Raibel and Bleiberg in Carinthia, Aix-la-Chapelle, Iserlohn, Tarnowitz, and Nertschinsk. In concentric botryoidal groups in the Mendip Hills, and at Wanlockhead, and in various pseudomorphs after calc-spar in Derbyshire. It is used as an ore of zinc, and in the manufacture of brass.

	Silica.	Zinc oxide.	Watr.	Lead oxide.	Total.	
1	25·0	68·3	4·4	...	97·4	Smithson, Retzbanya.
2	25·0	66·0	9·0	...	100	Berthier, Limburg.
3	25·5	64·5	10·0	...	100	Do. Breisgau.
4	23·2	66·8	10·8	...	100·8	Thomson, Leadhills.
5	25·38	62·85	9·07	2·70	100	Hermann, Nertschinsk (G. = 3·871).
6	25·96	65·66	8·38	...	100	Do. Do. (G. = 3·435).
7	24·89	66·84	7·46	0·27*a*	99·92	Berzelius, Limburg.

(*a*) With tin oxide + 0·54 carbonic acid.

269. WILLIAMITE, *Lévy;* Brachytype Zinc-Baryte, *Mohs.*

Rhombohedric; R 128° 30′; usual combinations ∞R . R, the crystals small, often very small. It also occurs massive and reniform. Cleavage, basal rather perfect, prismatic along ∞R imperfect; brittle; H. = 4·5; G. = 4·1 — 4·2. Translucent or transparent; lustre dull resinous; colour white, yellowish, or brown. B.B. in closed tube yields much water, otherwise acts like galmei. Chem. com. $\dot{Z}n^2\,\dot{S}i$ = 72·47 zinc oxide and 27·53 silica. Analyses.

	Silica.	Zinc oxide.	Mang. perox.	Iron perox.	Alumina.	Watr.	Total.	
1	25·00	71·33	2·66	0·67	...	...	99·66	Vanuxem, New Jersey.
2	26·97	68·77	...	1·48	0·66*a*	1·25	99·91	Thomson.
3	27·34	70·82	...	1·81*b*	...	...	99·97	Rosengarten, Upper Silesia

(*a*) + 0·78 alumina with zinc and iron; (*b*) protoxide.

Found with galmei at Aix-la-Chapelle, Liege, and Raibel, and at Franklin in New Jersey.

270. TRIPLITE, *Hausmann;* Phosphate of Manganese, *Jameson, Phillips;* Eisenpecherz, *Werner;* Manganèse phosphaté ferrifère, *Hauy;* Prismatic Retin-Baryte, *Mohs.*

Rhombic, but dimensions unknown, having only been found massive and coarse granular. Cleavage in three directions at right angles to each other, one rather perfect, the second less distinct, the third imperfect. Fracture flat conchoidal or uneven; H. = 5 — 5·5; G. = 3·6 — 3·8; translucent or opaque; lustre resinous; colour chesnut-brown or blackish-brown; streak yellowish-grey. In the open tube (or with sulphuric acid, *Gmelin*) shows traces of fluorine. B.B. on charcoal fuses easily, with strong intumescence, to a black metallic, highly magnetic globule; with soda on platina wire forms a green glass; with borax in the outer flame a glass coloured by manganese, in the inner by iron. Soluble in hydrochloric acid. Chem. com., according to Berzelius, $\dot{M}n^4\,\ddot{P} + \dot{F}e^4\,\ddot{P}$ = 34 iron protoxide, 33 manganese protoxide, and 33 phosphoric acid. Analyses, next page.

	Iron.	Manganese.	Phosphoric acid.	Phosphate of lime.	Total.	
1	31 *a*	42 *a*	27	...	100	Vauquelin, Limoges
2	31·95 *b*	32·6 *b*	32·8	3·2	100·5	Berzelius, Do.

(*a*) Peroxide; (*b*) protoxide.

It occurs with beryl in a quartz vein in granite at Limoges in France.

271. ZWIESELITE, *Breithaupt;* Eisenapatit, *Fuchs*, *Dufrénoy.* Rhombic, but hitherto only massive. Cleavage in three directions, basal rather perfect, brachydiagonal less perfect, prismatic along ∞P 129° very imperfect. Fracture conchoidal or uneven; H. = 4·5 — 5; G. = 3·95 — 4. Translucent on the edges; lustre resinous; colour brown; streak yellow. B.B. decrepitates and fuses easily to a bluish-black magnetic globule. With fluxes acts like triplite. Easily soluble in warm sulphuric acid, showing traces of fluorine. Chem. com. 2 $\dot{Fe}^3\,\dddot{P} + \dot{Mn}^3\,\dddot{P}$ + Fe F, or, by Fuch's analysis, 35·60 phosphoric acid, 35·44 iron protoxide, 20·34 manganese protoxide, 4·76 iron, 3·18 fluorine, 0·68 silica (= 100.) It occurs at Zwiesel in Bavaria; and externally is very like triplite, but its chemical composition is analogous to that of apatite.

272. TRIPHYLINE, *Fuchs*, *&c.* Rhombic, but dimensions unknown; chiefly found in coarse granular, crystalline masses. Cleavage, basal perfect, prismatic along ∞P 132°, and brachydiagonal imperfect. H. = 4 — 5; G. = 3·5 — 3·6. Translucent on the edges; lustre resinous; colour greenish-grey with blue spots, but when weathered becomes brown and opaque; yields water in the closed tube. B.B. fuses very easily to a dark steel-grey magnetic bead, colouring the flame pale bluish-green or red, the green more distinct when it is moistened with sulphuric acid. With borax shows reaction for iron, with soda for manganese. Easily soluble in hydrochloric acid, the residue after evaporation imparting a purple-red colour to the flame of alcohol. Chem. com. 6 ($\dot{Fe}^3$, $\dot{Mn}^3$) $\dddot{P}$ + $\dot{Li}^3\,\dddot{P}$, with 42·64 phosphoric acid, 49·16 iron protoxide, 4·75 manganese protoxide, and 3·45 lithia.

	Phosphoric acid.	Iron prot.	Mang. prot.	Lithia	Silica.	Magnesia.	Watr.	Total.	
1	41·47	48·57	4·70	3·40	0·53	...	0·68	99·35	Fuchs, Bodenmais (fresh).
2	35·70	48·17	8·94	...	1·40	...	5·30	99·51	Do. Do. (weathered).
3	42·6	38·6	12·1	8·2	...	1·7	...	103·2	Berzelius, Keiti.

Triphyline occurs at Rabenstein near Bodenmais in Bavaria in granite. No. 3 is *Tetraphyline* or *Perowskine* from Keiti in Tammela parish in Finnland. The latter agrees in general character with the triphyline, but is yellow when fresh, and black when weathered.

The last three minerals are closely allied to each other, and also to the following two species.

273. HUREAULITE, *Alluaud, Dufrénoy;* Huraulite, *Phillips, Mohs.*

Monoclinohedric; C = 68°, ∞P 62° 30′, P 88°; usual combination ∞P . 0P . P, the faces of the prism vertically striated, and the crystals small. Also in rounded masses, with a columnar or granular texture, and drusy surface. Cleavage unknown; fracture conchoidal or uneven. H. = 3·5; G. = 2·27. Translucent; lustre resinous; colour reddish-yellow or brown. Yields water in the closed tube. B.B. fuses easily to a black metallic-looking globule. Soluble in acids. Chem. com. 3 $\dot{Mn}^5\ddot{P}^2 + \dot{Fe}^5\ddot{P}^2 + 32\,\dot{H}$, or $\dot{R}^5\ddot{P}^2 + 8\,\dot{H}$. An analysis by Dufrénoy gave 38·00 phosphoric acid, 11·10 iron protoxide, 32·85 manganese protoxide, 18·00 water (= 99·95).

It is found in geodes and small veins in granite at Hureaux near Limoges in France.

Beraunite of Breithaupt occurs in small foliated and radiated masses, with one distinct and one indistinct cleavage at right angles. H. = 2; G. = 2·87. Lustre vitreous or pearly on the cleavage faces; colour hyacinth-red or reddish-brown; streak reddish ochre-yellow. According to Plattner, it consists of phosphate of iron peroxide and water. In the closed tube yields water. B.B. in forceps melts and colours the flame bluish-green. Soluble in hydrochloric acid. It is found with other phosphates of iron in the limonite at St Benigna near Beraun in Bohemia. Some analyses of kakoxene (see wavellite) are similar.

274. HETEROZITE, *Alluaud, Dufrénoy, Mohs;* Heteposite, *Phillips, Naumann.*

Rhombic or monoclinohedric, but only found massive. Cleavage, prismatic along ∞P 100°, and macrodiagonal; fracture uneven. Rather easily frangible. H. = 4·5 — 5·5; G. = 3·39 — 3·5 (when fresh 3·524, Dufrénoy). Opaque, or when light coloured, translucent on the edges; lustre vitreous or resinous; colour dark-violet or lavender-blue, to greenish-grey. Streak violet-blue or crimson-red. B.B. fuses to a dark-brown or black globule, with semimetallic lustre. Soluble in hydrochloric acid. Chem. com. 2 $\dot{Fe}^5\ddot{P}^2 + \dot{Mn}^5\ddot{P}^2 + 6\,\dot{H}$, or $\dot{R}^5\ddot{P}^2 + 2\,\dot{H}$. Dufrénoy's analysis gave 41·77 phosphoric acid,

34·89 iron protoxide, 17·57 manganese protoxide, 4·40 water, and 0·22 silica (= 98·85).

Occurs in granite at Hureaux near Limoges in France. Fuchs considers it a weathered triphyline, which it much resembles.

275. Alluaudite, *Damour.*

Rhombic probably; with cleavage in three directions at right angles to each other, one very easily obtained, the second less so, the third imperfect. Occurs massive. Fracture scaly and shining. H. above 4; G. = 3·468. Translucent on the edges, or opaque; lustre dull; colour clove-brown; streak yellowish-brown. In the closed tube it decrepitates and yields a little water. B.B. on platina wire fuses to a black magnetic globule; in the outer flame soluble in salt of phosphorus, with reaction for manganese. In hydrochloric acid, when cold, forms a black solution, which, when heated, becomes yellowish-brown. Difficultly soluble by long digestion in warm nitric acid. Chem. com. $(\dot{M}n, \dot{N}a)^3\ \ddot{P} + \ddot{F}e\ \ddot{P} + \dot{H}$, according to Damour, who found, on a mean of several analyses, 41·25 phosphoric acid, 25·62 peroxide of iron, 23·08 manganese protoxide, 1·06 manganese peroxide, 5·47 soda, 2·65 water, and 0·60 silica (= 99·73). It occurs in the pegmatite of Chanteloube near Limoges in the Haute-Vienne in France, along with vivianite and dufrénite. The alluaudite analyzed by Vauquelin was a variety of the latter.

276. Pitticite, *Hausmann;* Eisenpecherz, *Karsten;* Pitchy iron ore, *Phillips;* Eisensinter, *Werner;* Iron Sinter, *Allan;* Arsenicsensinter, *Naumann;* Fer oxide resinite, *Hauy;* Uncleavable Retin-Allophane, *Mohs.*

Amorphous, reniform, and stalactitic. Brittle; fracture conchoidal. H. = 2—3; G. 2·3—2·5. Semitransparent or translucent on the edges. Lustre resinous, inclining to vitreous; colour yellowish, reddish, or blackish-brown, sometimes in spots or stripes. Streak light ochre-yellow or yellowish-white. In the closed tube yields much water, with acid reaction. On ignition emits sulphurous odours. B.B. on charcoal fuses easily, with effervescence and strong arsenical fumes, to a black magnetic globule. Easily soluble in hydrochloric acid to a yellow fluid. Chem. com. according to Stromeyer's analysis, $\ddot{F}e\ \dddot{A}s + \ddot{F}e\ \ddot{S} + 15\ \dot{H} = 35$ iron peroxide, 26 arsenic acid, 9 sulphuric acid, and 30 water. Analyses, next page.

This mineral occurs in many old mines, especially those near Freiberg, and also at Schneeberg in Saxony, Pless in Silesia, and Bleistadt in Bohemia. It is evidently a recent product, probably from the decomposition of mispickel. According to Freiesleben, it is first fluid,

	Iron perox.	Mang. perox.	Arsenic acid.	Sulph. acid.	Watr.	Total.	
1	33·10	0·64	26·06	10·04	29·26	99·10	Stromeyer, Freiberg.
2	35	trace	20	14	30	99	Laugier, Do.
3	40·45	...	30·25	...	28·50	99·20	Kersten, Do.
4	54·66	...	24·67	5·20	15·47	100	Rammelsberg, Gastein.
5	58·00	...	28·45	4·36	12·59	100	Do. Do.

and gradually separates in a solid form. Nos. 3 and 4 seem mixtures of various metallic salts. It agrees in all external characters with the diadochite.

277. Diadochite, *Breithaupt.*

Reniform and stalactitic, with a curved lamellar structure. Fracture conchoidal; very easily frangible; H. = 3; G. = 2·035. Translucent or opaque; lustre resinous, inclining to vitreous; yellow or yellowish-brown; streak white. In the closed tube it yields water. B.B. colours the flame green, intumesces slightly, and fuses on the edges to a black magnetic enamel; with fluxes shows reaction for iron. Chem. com. $\dddot{\mathrm{Fe}}\,\dddot{\mathrm{P}}^2 + 4\,\dddot{\mathrm{Fe}}\,\dddot{\mathrm{S}} + 32\,\dot{\mathrm{H}}$, according to L. Gmelin, from Plattner's analysis No. 1.

	Iron perox.	Phosphoric acid.	Sulphuric acid.	Watr.	Total.	
1	36·69	14·81	15·15	30·35	100	Plattner.
2	34·20	16·04	...	49·76	100	Dumont.
3	36·62	16·57	...	46·81	100	Do.

Diadochite is a recent formation found in the alum-slate mine near Gräfenthal and Saalfeld in Thuringia.

The *Delvauxine* of Dumont, Nos. 2, 3, is an allied but probably distinct species from Visé in Belgium. It is redddish (No. 2) or blackish (No. 3) brown, or yellow. H. = 2·5; G. = 1·85. B.B. decrepitates, and fuses to a grey magnetic bead. In hydrochloric acid forms a brown solution. In the original analyses from 9—11 per cent. of carbonate of lime, and 3·6—4·4 per cent. silica were found. A mineral named delvauxine was twice analyzed by Mr Sandall, who found 52·37 iron peroxide, 40·19 water, 3·95 silica, 2·62 phosphoric acid, and 0·87 lime (= 100). This substance is evidently distinct, and probably a mixture.

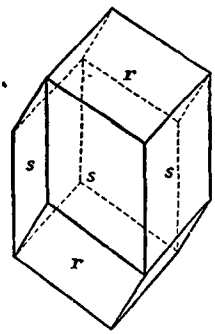
The *Karphosiderite* of Breithaupt, reniform, opaque, resinous, and straw-yellow, with a greasy feel, is closely related. H. = 4·5; G. = 2·5. B.B. becomes red and fuses to a black magnetic bead. It is found in fissures of mica slate on the coast of Labrador; and, according to Harkort, consists of hydrous phosphate of iron with a little oxide of zinc.

II. Family.—Copper-Salts.

278. Dioptase, *Hauy;* Kupfer-Smaragd, *Werner;* Emerald Copper, *Phillips;* Rhombohedral Emerald Malachite, *Mohs.*

Rhombohedric (probably hexagonal and tetartohedral); R 126° 17′, —2R 95° 48′, most common combinations ∞P2 (*s*). —2R (*r*) (fig. 192).

Fig. 192.



The crystals generally short prismatic, and attached or united in druses. Cleavage, rhombohedral along R, perfect; Brittle; H. = 5; G. = 3·2 — 3·3. Transparent or translucent; lustre vitreous; colour emerald-green, sometimes verdigris-green or blackish-green; streak green. In closed tube yields water. B B. in the outer flame becomes black, in the inner red, but is infusible; colours the flame green. On charcoal with soda forms a dark glass, enclosing a grain of copper. Soluble, and gelatinizes in hydrochloric or sulphuric acid, and also in ammonia. Chem. com. $\dot{C}u\,\dot{S}i + \dot{H} =$ 38·7 silica, 50 copper protoxide, and 11·3 water. Analyses.

	Silica.	Copper prot.	Watr.	Iron prot.	Alumina.	Lime.	Magnesia.	Total.	
1	36·60	48·89	12·29	2·00	...	...	...	99·78	Hess.
2	36·85	45·10	11·52	...	2·36	3·39	0·22	99·43	Do.
3	36·47	50·10	11·40	0·42*a*	...	0·35*b*	...	98·74	Damour.

(*a*) Peroxide; (*b*) carbonate.

This mineral has only been found in numerous small veins and druses along with calc-spar in a bed of compact limestone in the clayslate of the low hills of Altyn-tubeh, in the middle Kirghis Steppe, about 100 versts from Kar-Karaly. It was first brought to Europe by Bucharian merchants, and sold as emerald.

279. Chrysocolla, *Jameson;* Kupfergrün, Copper-green, *Werner;* Kieselmalachit, *Hausmann;* Cuivre hydrosilicieux, *Hauy;* Euchromatic Opaline-Allophane, *Mohs.*

Botryoidal, reniform, or investing; also massive and disseminated, or rarely forming pseudomorphs after azurite. Brittle; fracture conchoidal and fine splintery; H. = 2 — 3; G. = 2·0 — 2·3. Translucent on the edges, or semitransparent; lustre weak resinous, or

dull; colour verdigris to emerald-green or azure-blue; streak greenish-white. B.B. and with acids acts like dioptase. Chem. com. $\dot{C}u\,\dot{S}i + 2\,\dot{H} = 34{\cdot}83$ silica, 44·94 copper protoxide, and 20·23 water. Analyses.

	Silica.	Copper protox.	Iron perox.	Watr.	Carb. acid.	Vein-stone.	Total.	
1	40	40	...	12	8	...	100	Ullmann, Siegen.
2	36·54	40·60	1·00	20·20	...	2·10	99·84	v. Kobell, Bogoslowsk.
3	35·0	39·9	3·00	21·0	...	1·1	100·00	Berthier, Do.
4	26·0	41·8	2·5	23·5	3·7	2·5	100	Do. Canaveilles.
5	35·4	35·1	...	28·5	...	1·0	100	Do. Somerville, N. J.
6	37·25	45·17	...	17·00	...	...	99·42	Bowen, Do.
7	35·14	43·07	1·09*a*	20·36	...	...	99·66	Scheerer, Sätersdal, Norway.
8	40·0	42·6	1·4	16·0	...	...	100·00	Beck, Franklin, N. J.
9	9·66	13·00	59·00	18·00	...	..	99·66	v. Kobell, Turjinsk, Ural.

(*a*) With alumina, lime, and potash.

No. 7, dried at 212°, had G. = 3·317; No. 9, of a brown colour, is a mixture with limonite, and some of the others were probably also impure. It seems a secondary production from the decomposition of copper ores, which it usually accompanies at the above localities, and also in Cornwall, Hungary, the Tyrol, Moldawa in the Bannat, in Spain, the Harz, Mexico, and Chili. Fine pseudomorphs occur at Bogoslowsk in the Ural, and the crystals mentioned by Hauy (right rhombic prisms of 103° 20′) were probably of this nature.

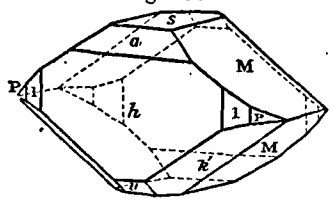
The *Malachithiesel*, *Siliceous-malachite* of Zincken, from Lauterberg in the Hartz, seems only a variety of chrysocolla. The *Kupferblau* of Breithaupt, from the Schappachthal in Baden, also agrees with it, except in its somewhat greater hardness (= 4 — 5) and higher specific gravity (= 2·56). Plattner finds in it 36·3 per cent. copper, = 45·5 of copper protoxide. The *Kupferblau* of G. Rose, from Turjinsk in the Ural, light azure-blue, with bluish-white streak, is perhaps distinct. In warm hydrochloric acid the copper is dissolved with violent effervescence, leaving the silica in the form of the assay.

280. AZURITE, *Beudant;* Blue Copper, *Jameson;* Blue Carbonate of Copper, *Phillips;* Kupferlasur, *Werner;* Cuivre carbonaté bleu, *Hauy;* Hemiprismatic Lasur-Malachite, *Mohs.*

Monoclinohedric; C = 87° 39′, ∞P (*M*) 99° 32′, —P (*h*′) 106° 14′. The greater number of crystals consist essentially of 0P . ∞P . ∞P∞ . —P, or *h*, *M*, *s*, *h*′, in fig. 193 of a common form from Chessy as drawn by Mohs, who places the crystals in a different position from that here assumed after Naumann and G. Rose, who make *M* the vertical prism ∞P. Many still more complex forms also occur. The crystals are usually short prismatic or thick tabular, but occasionally

lengthened along the orthodiagonal. Single crystals are rare, more commonly they are combined in druses or groups. It also occurs massive, and disseminated in radiated or compact and earthy varieties. Cleavage clinodomatic along (P∞) (*P*) 59° 14′, rather perfect. Fracture conchoidal, or uneven and splintery; H. = 3·5 — 4; G. = 3·7 — 3·8. Translucent or opaque; lustre vitreous; colour azure-blue, the earthy varieties (and streak) smalt-blue. In the closed tube it gives out water and becomes black. B.B. on charcoal fuses and yields a grain of copper. Soluble with effervescence in acids, and also in ammonia. Chem. com. $\dot{C}u^3\ddot{C}^2 + \dot{H}$, with 69·09 protoxide of copper, 25·66 carbonic acid, and 5·22 water. Analyses.

Fig. 193.



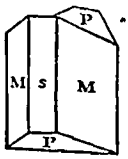
	Copper oxide.	Carb. acid.	Watr.	Total.	
1	70	24	6	100	Klaproth, Turjinsk, Ural.
2	69·08	25·46	5·46	100	Phillips, Chessy, Lyons.
3	68·5	25·0	6·5	100	Vauquelin, Do. Do.

The azurite occurs in beds or veins, chiefly with malachite and other ores of copper. The finest crystals are found at Chessy near Lyons in France, in a great variety of forms, and very brilliant colours. Kolywan and Nischne-Tagilsk in Siberia also furnish fine specimens; and those from Moldawa in the Bannat, though small, are very distinct. It has also been occasionally found near Redruth in Cornwall, at Alston moor, and Wanlockhead. Massive varieties occur in Cornwall, and earthy in Thuringia, the Harz, and Hessia, and in great abundance in the Permian rocks on the west side of the Ural. Where in sufficient quantities, it is valued as an ore of copper.

281. MALACHITE, *Werner;* Green Carbonate of Copper, *Phillips;* Cuivre carbonaté vert, *Hauy;* Hemiprismatic Habroneme-Malachite, *Mohs.*

Monoclinohedric, C = 61° 49′, ∞P 103° 42′; but distinct crystals are rare, the most common being the prismatic combination ∞P (*M*). ∞P∞ (*s*) . 0P (*P*), again united in macles by a face of ∞P∞ (fig. 194). In general, it occurs acicular and capillary, thin tabular, and scaly, or in botryoidal, reniform, stalactitic aggregates, with a curved lamellar or radiated fibrous structure, often becoming compact. Also massive, disseminated, and encrusting, or as a pseudomorph after azurite or cuprite (red-copper-ore). Cleavage, basal and clinodia-

Fig. 194.



gonal very perfect. The massive varieties have partly a diverging and radiated fibrous, or very fine splintery fracture. H. = 3·5 — 4; G. = 3·6 — 4. Transparent or translucent only on the edges; lustre adamantine or vitreous in the crystals; silky or dull in the aggregates; colour emerald and other shades of green; streak apple-green. B.B., and with acids, acts like azurite. Chem. com. $\dot{C}u\,\ddot{C} + \dot{H}$, with 71·8 copper protoxide, 20 carbonic acid, and 8·2 water. Analyses.

	Copper oxide.	Carbon. acid.	Watr.	Total.	
1	70·5	18·0	11·5	100	Klaproth, Turjinsk (compact).
2	70·10	21·25	8·75	100·10	Vauquelin, Chessy (fibrous).
3	72·2	18·5	9·3	100	Phillips, Do. Do.

Malachite seems in many cases a recent production, caused by the action of the water and carbonic acid of the atmosphere on other copper ores. It is slightly soluble in water, containing carbonic acid, and hence its stalactitic forms and wide dissemination in rocks may be explained. The foliated, fibrous, compact, and earthy malachites have been distinguished, but they all appear together, and pass into each other. The foliated or crystalline varieties are rare, but occurred at Rheinbreitenbach on the Rhine, and Zellerfeld in the Harz. Beautiful specimens of the fibrous variety are found at Chessy in France, at Saalfeld in Thuringia, Moldawa in the Bannat, in the old mine at Sandlodge in Zetland, and in several places in North America and Australia. The compact variety is found chiefly at Falkenstein near Schwatz in the Tyrol, but also in Cornwall, Wales, and Ireland. The copper mines of Siberia and the Ural furnish the finest specimens of malachite, often in masses of immense size. One mass at Nischne Tagilsk was estimated to weigh 15,000 pouds, or half a million pounds. It is a valuable ore of copper, and the finer varieties are prized for ornamental purposes, from their brilliant colours and high polish.

The *Lime-Malachite, Kalkmalachite* of Zinken, occurs microcrystalline, in reniform, and botryoidal masses, with a radiated fibrous or foliated structure. Brittle; H. = 2·5. Lustre silky; colour verdigris-green. In the closed tube it yields water, and becomes black. B.B. becomes black and fuses to a black slag, which with soda gives copper. Soluble in hydrochloric acid, leaving gelatinous gypsum (*Zinken*). It seems a hydrous carbonate of copper and carbonate of lime, with sulphate of lime and some iron. It occurs at Lauterberg in the Harz, but is perhaps only an impure malachite. The *Mysorine* of Thomson from Mysore in the East Indies, compact, blackish-brown, and soft, with G. = 2·62, seems a mixture of a carbonate of copper with iron peroxide.

282. AURICHALCITE, *Böttger.*

Occurs in acicular crystals, H. = 2. Translucent, pearly, and verdigris-green. In the closed tube yields water, and becomes black. B.B. on charcoal in the inner flame forms a deposition of zinc oxide, and with fluxes gives reaction for copper. Soluble with effervescence in hydrochloric acid. Chem. com. nearly $\dot{Zn}^3\,\ddot{C} + \dot{Cu}^2\,\ddot{C} + 3\,\dot{H}$, with 29·2 copper protoxide, 44·7 zinc oxide, 16·2 carbonic acid, and 9·9 water. Analyses.

	Copper protox.	Zinc oxide.	Lime.	Carbonic acid.	Watr.	Total.	
1	28·19	45·84	...	16.05	9·95	100·05	Böttger, Loktewsk.
2	28·36	45·62	...	16·08	9·93	99·99	Do. Do.
3	32·5	42·7	...	27·5		102·7	Connell, Matlock.
4	29·46	32·02	3·62	21·45	8·45	100	Delesse, Loktewsk.
5	29·00	41·19	2·16	19·88	7·62	99·85	Do. Chessy, G. = 3.32.

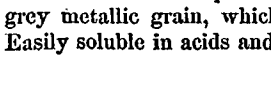
The Aurichalcite occurs at Loktewsk and other places in the Altai, with calcspar. No. 3 seems identical in composition, but the quantity analyzed was only 3·16 grains, and it contained also traces of magnesia and lime.

Buratite of Delesse, Nos. 4 and 5, is azure-blue, and in most characters agrees with aurichalcite, but differs slightly in composition, being perhaps $(\dot{Cu}^2, \dot{Zn}^2, \dot{Ca}^2)\,\ddot{C} + \dot{H}$; or a malachite, with part of the copper protoxide replaced by zinc protoxide and lime. It accompanies galmei at Loktewsk; and, according to Delesse, similar substances are found in the maremma of Volterra in Tuscany, at Framont in Tyrol, and in Siberia.

283. CHALCOPHYLLITE, *Breithaupt;* COPPER-MICA, *Jameson;* Kupfer-Glimmer, *Werner;* Rhomboidal Arseniate of Copper, *Phillips;* Rhombohedral Euchlore-Malachite, *Mohs.*

Rhombohedral, R 68° 45′ (*Brooke*). The crystals are always tabular from the predominance of 0R (*o*), bounded on the sides by faces of R (fig. 195). It occurs in small druses and foliated masses. Cleavage, basal very perfect. Sectile. H. = 2; G. = 2·4 — 2·6. Translucent or transparent; lustre pearly on 0R, on other faces vitreous inclining to adamantine; colour emerald to grass or verdigris-green; streak light-green. In closed tube decrepitates violently and yields much water. B.B. on charcoal in powder emits arsenical vapours, and fuses to a grey metallic grain, which, fused with soda, yields pure copper. Easily soluble in acids and ammonia. Analyses, next page.

Fig. 195.



	Arsenic acid.	Copper protox.	Iron protox.	Watr.	Alumina.	Phosphoric acid.	Total.	
1	21	58	...	21	...	...	100	Chevenix.
2	43	39	...	17	...	...	99	Vauquelin.
3	17·51	44·45	2·93	31·19	3·93		100	Hermann (G. = 2·435).
4	19·35	52·92	...	23·94	1·80	1·29	99·30	Damour (G. = 2·659).
5	21·27	52·30	...	22·58	2·13	1·56	99·84	Do. (Do.)

The above analyses are all of specimens from Cornwall. Hermann rejects the phosphoric acid and alumina as impurities, and adds the protoxide of iron to the copper, which gives the formula $\dot{C}u^8\,\dddot{A}s + 23\,\dot{H}$, with 49·61 copper protoxide, 18·02 arsenic acid, and 32·37 water. Damour again rejects the alumina and adds the phosphoric to the arsenic acid, and gives $\dot{C}u^6\,\dddot{A}s + 12\,\dot{H}$, with 51·6 copper protoxide, 25 arsenic acid, and 23·4 water. These formulæ do not, however, well express the analyses, which again differ widely from each other. It is also remarkable that Nos. 3, 4, 5 all contain phosphoric acid and alumina, which thus seem essential constituents.

This mineral has been chiefly found with other copper ores in veins in killas in Cornwall, especially in Tingtang, Wheal Gorland, and Wheal Unity mines near Redruth. Also, it is said, near Saida in Saxony, and at Moldawa in the Bannat.

284. TIROLITE, *Haidinger;* Kupferschaum, *Werner*, *Allan*, *Phillips;* Copper Froth, *Dana;* Prismatic Euchlore Malachite, *Mohs.*

Crystallization unknown (rhombic, *Hausmann*). Only found in reniform, or small, massive aggregates with a radiating foliated texture and drusy surface. Cleavage in one direction very perfect; sectile. Thin laminæ flexible; H. = 1·5 — 2; G. = 3 — 3·1. Translucent; lustre pearly; colour verdigris-green to azure-blue; streak similar but paler. B.B. decrepitates violently and fuses to a steel-grey bead. On charcoal yields arsenical odours. Soluble in acids, evolving carbonic acid; and in ammonia leaves carbonate of lime. Chem. com. perhaps hydrated arseniate of copper with carbonate of lime, or $(\dot{C}u^5\,\dddot{A}s + 10\,\dot{H}) + \dot{C}a\overset{\frown}{\dot{C}}$, or by von Kobell's analysis of a variety from Falkenstein, 43·88 copper oxide, 25·01 arsenic acid, 17·46 water, and 13·65 carbonate of lime (= 100). But the water is nearer 9 atoms, and the carbonate of lime perhaps accidental. It occurs in beds and veins with other copper ores, especially at Falkenstein and other parts of the Tyrol. Also at Libethen in Hungary, Reichelsdorf in Hessia, Saalfeld in Thuringia, Schneeberg in the Erzgebirge, Campiglia near Piombino in Italy, in Asturia and at

Linares in the Sierra Morena in Spain, and at Matlock in Derbyshire.

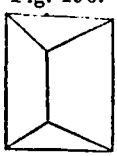
285. ERINITE, *Haidinger*, *Phillips;* Monotomous Dystome-Malachite, *Mohs.*

Porodine and amorphous (*Breithaupt*) in reniform masses with concentric foliated structure, rough surface, and conchoidal fracture; H. = 4·5 — 5; G. = 4 — 4·1. Translucent on the edges; dull resinous lustre; colour emerald or grass-green; streak similar. Chem. com. $\dot{Cu}^5 \ddot{As} + 2\dot{H}$, or by an approximative analysis by Turner, 59·44 copper protoxide, 33·78 arsenic acid, 5·01 water, 1·77 alumina (= 100). It occurs at Limerick in Ireland with olivenite and other copper ores. According to Haidinger, erinite has a crystalline or relatively symmetrical structure, with scarcely perceptible traces of cleavage in one direction. The same name is applied to the chalcophyllite (especially Nos. 3, 4, 5 above); and Thomson has also given it to a wholly distinct mineral (compare p. 221 above).

286. LIROCONITE, *Beudant;* Linsenerz, *Werner;* Octahedral Arseniate of Copper, *Phillips;* Chalcophacite, *Glocker;* Prismatic Lirocon-Malachite, *Mohs.*

Rhombic; usual combination $\infty P \cdot \bar{P}\infty$, short prismatic or rectangular pyramidal; $\infty P = 119° 45'$, $\bar{P}\infty = 71° 50'$. The crystals (fig. 196) are small and combined in druses. Cleavage, prismatic along $\bar{P}\infty$ imperfect, and along $P\infty$ still less perfect; H. = 2 — 2·5; G. = 2·8 — 3·0. Translucent; lustre vitreous, or resinous on fracture; colour azure-blue to verdigris-green; streak paler. In the closed tube does not decrepitate, yields much water, and becomes green; then begins to ignite, and appears brown. B.B. on charcoal emits arsenical vapours, and fuses with intumescence to a mass containing grains of copper. Soluble in acids and in ammonia. Chem. com. $\dot{Cu}^8 \ddot{As} + \ddot{Al} \ddot{As} + 24\dot{H}$, with 36·6 copper protoxide, 11·9 alumina, 26·6 arsenic acid, and 24·9 water. Analyses.

Fig. 196.



	Copper protox.	Alumina.	Iron perox.	Arsenic acid.	Phosphoric acid.	Water.	Total.	
1	35·19	8·03	3·41	20·79	3·61	22·24*a*	100·26	Trolle-Wachtmeister.
2	37·73	8·61	3·66	22·29	3·97	23·84	100	Do. corrected.
3	36·38	10·35	0·98	23·05	3·73	25·01	100	Hermann (G. = 2·985).
4	37·18	9·68	...	22·22	3·49	25·49	98·06	Damour (G. = 2·964).
5	37·40	10·09	...	22·40	3·24	25·44	98·47	Do. Do.

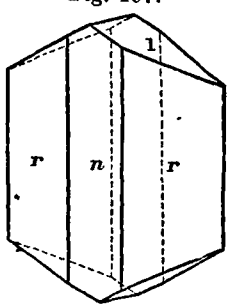
(*a*) + 4·04 silica and 2·95 veinstone (omitted in No. 2).

These analyses are of varieties from Cornwall, where this mineral has been chiefly found, as in Wheal Unity and other mines near Redruth in veins with quartz and ores of copper and iron. It is also found in small crystals at Herrengrund in Hungary and Ullersreuth in the Voightland. Breithaupt describes this mineral as monoclinohedric, and Damour says the azure-blue crystals he analyzed belonged to the same system.

287. OLIVENITE, *Jameson;* Olivenerz, *Werner;* Right Prismatic Arseniate of Copper, *Phillips;* Pharmakochalcit, *Hausmann;* Prismatic Oliven-Malachite, *Mohs.*

Rhombic; ∞P 92° 30′, $\breve{P}\infty$ 110° 50′, usual combination ∞P (*r*). $\breve{P}\infty$ (*l*) . $\infty\breve{P}\infty$ (*n*) (fig. 197). The crystals are short or long prismatic, or acicular; and either attached singly or united in druses. It also occurs in spherical and reniform aggregates with a fine columnar or fibrous texture. Cleavage, prismatic (along *r*), and brachydomatic (along *l*), very imperfect, H. = 3; G. = 4·2 — 4·6. Pellucid in all degrees; lustre vitreous, resinous, or silky; colour leek, olive, or blackish-green, also yellow and brown; streak olive-green or brown. In the closed tube yields water and becomes first green, then greyish-black. B.B. in the forceps fuses easily to a dark-brown, adamantine bead covered with radiating prismatic crystals. On charcoal, detonates, emits arsenical vapours, and is reduced to copper. Soluble in acids and ammonia. Chem. com. Cu^4 ($\dddot{A}s$, $\dddot{P}$) + H, with 56·5 copper protoxide, 39·5 arsenic acid, and 4 water. Analyses.

Fig. 197.



	Copper oxide.	Arsenic acid.	Phosphoric acid.	Water.	Total.	
1	56·43	36·71	3·36	3·50	100	V. Kobell, massive.
2	56·2	39·9	...	3·9	100	Richardson, do.
3	56·65	39·80	...	3·55	100	Do. acicular
4	56·38	33·50	5·96	4·16	100	Hermann, (G. = 4·135).
5	56·86	34·87	3·43	3·72	98·88	Damour (G. = 4·378).
6	54·98	40·61	...	4·41	100	Thomson, fibrous.
7	51·03	40·50	1·00	3·83*a*	100	Hermann, fibrous (G. = 3·913.)

(*a*) + 3·64 protoxide of iron.

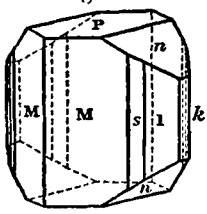
The specimens were from Cornwall, where this mineral has been chiefly found in veins with other arseniates of copper, especially in the mines of Carrarach, Tin Croft, Gwennap, and St Day. It also

occurs in less beauty at Alston Moor; at Kamsdorf and Saalfeld in Thuringia; at Schwatz in the Tyrol, in the Bannat, at Nischne-Tagilsk in Siberia, in Asturia, Chili, and several other places. Like the other arseniates of copper, it seems a recent formation from the decomposition of fahlore containing arsenic.

288. EUCHROITE, *Breithaupt, Phillips;* Prismatic Emerald Malachite, *Mohs.*

Rhombic, ∞P 117° 20′, P̆∞ 87° 52′; usual combination ∞P (*M*) . ∞P̆2 (*l*) . 0P (*P*) . P̆∞ (*n*) (fig. 198). Crystals short prismatic, small, and vertically striated. Cleavage, prismatic and brachydomatic imperfect; rather brittle; H. = 3·5 — 4; G. = 3·35 — 3·45; transparent or translucent; lustre vitreous; colour emerald or leek-green; streak verdigris-green. In the closed tube yields water without decrepitating, but becomes yellowish-green, and friable. B.B. in forceps fuses, and on cooling forms a greenish-brown crystallized mass; on charcoal detonates and fuses with arsenical odours, leaving a grain of copper. Ignited with charcoal powder in the open tube it yields a sublimate of arsenic and arsenious acid. Easily soluble in nitric acid. Chem. com. $\dot{Cu}^4 \dddot{As} + 7\dot{H}$ = 47·1 copper protoxide, 34·2 arsenic acid, and 18·7 water. Analyses.

Fig. 198.



	Copper oxide.	Arsenic acid.	Lime.	Watr.	Total.	
1	47·85	33·02	...	18·80	99·67	Turner.
2	46·97	34·42	...	19·31	100·70	Kühn.
3	46·99	32·42	1·12	19·31	99·84	Do.
4	48·09	33·22	...	18·39	99·70	Wöhler.

Wöhler also found traces of iron, nickel, and phosphoric acid. This mineral has hitherto occurred only at Libethen near Neusohl in Hungary in a quartzose mica slate.

289. KLINOCLASE, *Breithaupt;* Strahlerz, *Werner, Allan;* Oblique prismatic Arseniate of Copper, *Phillips;* Aphanese, *Beudant;* Abichite, *Haidinger;* Diatomous Habroneme-Malachite, *Mohs.*

Monoclinohedric, C = 85°, ∞P 56°, usual combination ∞P . P∞ . —P∞, in which the two hemidomes form a horizontal edge of 100° 42′. Crystals prismatic in the direction of ∞P. It also forms wedge-shaped and hemispherical aggregates, with a radiated columnar texture. Cleavage, basal highly perfect, the cleavage planes in the ag-

gregates curved. H. = 2·5 — 3; G. = 4·2 — 4·4. Translucent or opaque; lustre vitreous; pearly on the cleavage planes; colour externally blackish-green, internally dark verdigris-green inclining to sky-blue; streak bluish-green. B.B. becomes black when heated, and on charcoal leaves a grain of malleable copper. It is soluble in acids and in ammonia. Chem. com. $\dot{Cu}^6 \dddot{As} + 3\,\dot{H}$, or $\dot{Cu}^2 \dddot{As} + 3\,\dot{Cu}\,\dot{H}$, analogous to the phosphorochalcite, with 62·6 copper protoxide, 30·3 arsenic acid, and 7·1 water. Analyses.

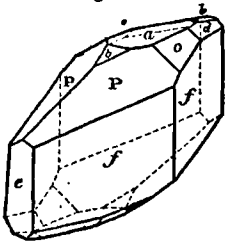
	Arsenic acid.	Phosphoric acid.	Copper prot.	Watr.	Iron perox.	Lime.	Silica.	Total.	
1	29·71	0·64	60·00	7·64	0·39	0·50	1·12	100·0	Rammelsberg (G. = 4·258).
2	27·08	1·50	62·30	7·57	0·49	...	...	99·44	Damour (G. = 4·312).

Found chiefly with other copper ores in veins in Cornwall (Nos. 1 and 2), and also near Saida in the Erzgebirge. The specific gravity of No. 1 in powder was 4·359.

290. PHOSPHOROCHALCITE, *v. Kobell;* Hydrous Phosphate of Copper, *Phillips;* Cuivre phosphaté, *Haüy;* Pseudomalachite, *Hausmann;* Hemiprismatic Dystome Malachite, *Mohs.*

Monoclinohedric; the most common forms are (∞P2) (*f*) 38° 56′, P (*P*) 117° 49′, united with the almost horizontal basis 0P (*a*) and ∞P∞ (*e*), combined in short prismatic crystals (fig. 199); usually small and indistinct. It is more common in spherical, reniform, or botryoidal masses, with a radiated, fibrous texture, and drusy surface. Cleavage, orthodiagonal imperfect. Fracture uneven and splintery. H. = 5; G. = 4·1 — 4·3. Translucent, but in general only on the edges. Lustre adamantine or resinous; colour blackish, emerald, or verdigris-green. B.B. decrepitates when heated quickly, when slowly blackens and fuses to a black globule containing a grain of copper. When this globule is fused with an equal volume of lead, a coat of phosphate of lead, crystallizing when cold, forms round the copper granule. Moistened with hydrochloric acid it colours the flame blue. Easily soluble in nitric acid or ammonia. Chem. com. according to Kühn, $\dot{Cu}^6 \ddot{P} + 3\,\dot{H}$, with 70·8 copper protoxide, 21·2 phosphoric acid, and 8 water; according to Arfvedson and Hermann, $\dot{Cu}^5 \ddot{P} + 2\,\dot{H}$, with 68·9 copper protoxide, 24·8 phosphoric acid, and 6·2 water. Analyses, next page.

Fig. 199.



	Copper oxide.	Phosphoric acid.	Water.	Total.	
1	68·13	30·95	...	99·08	Klaproth, Rheinbreitenbach.
2	62·85	21·09	15·45	99·99	Lynn, Do.
3	68·20	24·70	5·97	98·87	Arfvedson, Do.
4	68·74	21·52	8·64	98 90	Kühn, Do. (mean of 3).
5	67·25	24·55	8·20	100	Hermann, Do. (G. = 4·4).
6	68·75	23·75	7·50	100	Do. Nischne-Tagilsk (G. = 4·25).
7	67·73	23·47	8·80	100	Do. Do. (G. = 4·00).
8	68·21	25·30	6·49	100	Do. Do. (Dihydrite) (G. = 4·4).
9	71·73	20·87	7·40	100	Kühn, Hirschberg, Voightland.
10	69·61	24·13	6·26	100	Do. Libethen, Hungary.
11	67·00	24·22	8·78	100	Do. Do.

This mineral occurs in beds in greywacke, with quartz and various ores of copper, on the Virneberg near Rheinbreitenbach in Rhenish Prussia; and also at Nischne-Tagilsk in the Ural. Hermann names No. 8 *Dihydrite*, as it contains about a fifth less water, but in other respects it agrees with phosphorochalcite, and is probably not distinct. Nos. 10 and 11 are a fibrous variety, with a concentric foliated structure, which Kühn names *Copperdiaspore*, because when ignited it is thrown about violently without decrepitating. No. 11 nearly agrees with Ehlite. There is still much uncertainty regarding the composition of this and the other phosphates of copper.

291. THROMBOLITE, *Breithaupt, Dana.*

Porodine, with conchoidal fracture; rather brittle. H. = 3 — 4; G. = 3·38 — 3·40. Opaque; lustre vitreous; colour emerald, leek, or dark-green. In closed tube yields much water and becomes black. B.B. colours the flame blue and then green; on charcoal fuses to a black globule, which spreads out and shows grains of copper. With boracic acid and iron wire, it gives reaction for phosphoric acid. Chem. com. $Cu^3 \dddot{P}^2 + 6\,\dot{H}$, or by Plattner's approximate analysis, 41·0 phosphoric acid, 39·2 copper protoxide, and 16·8 water (= 97·0). It is found with malachite on limestone at Retzbanya in Hungary.

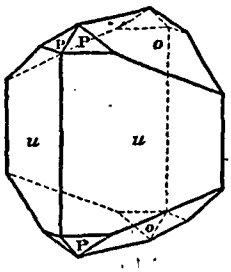
292 LIBETHENITE, *Breithaupt;* Phosphate of copper, *Phillips;* Olivenerz, *Werner*, in part; Diprismatic Oliven-Malachite, *Mohs.*

Rhombic, most common combination $\infty P \,.\, \breve{P}\infty \,.\, P$, forming short

	Copper protox.	Phospho-ric acid.	Water.	Total.	
1	63·9	28·7	7·4	100	Berthier, Libethen, crystallized.
2	64·8	22·8	9·0*a*	99·2	Do. Do. compact.
3	66·94	29·44	4·05	100·43	Kühn, Do. crystallized.
4	65·89	28·61	5·50	100	Hermann, Tagilsk.

(*a*) + 1·0 carbonic acid and 1·6 iron peroxide.

Fig. 200.



prismatic crystals (fig. 200) with ∞P (*u*) = 95°, and P̆∞ (*o*) = 112° (according to Rose, 92° and 109½°). The crystals are small, and attached singly or in druses. Cleavage, brachydiagonal and macrodiagonal imperfect. H. = 4; G. = 3·6 — 3·8. Translucent on the edges; lustre resinous; colour leek, olive, or blackish-green; streak olive-green. B.B. and with acids acts like the phosphorochalcite. Chem. com. $\dot{C}u^4\,\ddot{\dot{P}} + \dot{H}$, with 66·37 copper protoxide, 29·86 phosphoric acid, and 3·77 water. Analyses, foot of page 362.

The above formula is that given by Kühn's analysis, No. 3, from which No. 4 only differs in containing rather more water. Berthier's analysis, No. 1, contains twice the water, or 2 Ḣ, and agrees with that by Rhodius of ehlite below, which is probably the same mineral under a different name.

It occurs at Libethen in Hungary with quartz, enchroite, and copper pyrites in mica slate. It is also found at Tagilsk in the Ural, and in small quantity near Gunnislake in Cornwall. It is isomorphous with olivenite, whence G. Rose conjectured it should have a similar chemical composition, which is now confirmed by analysis.

293. TAGILITE, *Hermann.*

Forms fungoid, warty, or botryoidal masses, with a rough, earthy surface, and radiating fibrous or earthy fracture. H. = 3; G. = 3·5. Colour emerald-green, or when weathered mountain-green. Chem. com. $\dot{C}u^4\,\ddot{\dot{P}} + 3\,\dot{H}$, or, according to Hermann's analysis, 62·38 copper protoxide, 26·91 phosphoric acid, and 10·71 water (= 100). The original was mixed with about 2 per cent. of hydrated peroxide of iron. It occurs at Nischne-Tagilsk on limonite.

294. EHLITE, *Breithaupt.*

Botryoidal or reniform masses with a radiating foliated texture, and smooth shining surface. Also compact and disseminated. Cleavage, in one direction perfect. H. = 1·5 — 2 (even 4 (?) *Hermann*); G. = 3·8 — 4·27. Translucent on the edges; lustre pearly on the cleavage faces; verdigris-green in the interior, on the surface almost emerald-green. Streak pale verdigris-green. B.B. when heated it breaks into small fragments, which are thrown about violently, otherwise it acts like phosphorochalcite. Chem. com. $\dot{C}u^5\,\ddot{\dot{P}} + 3\,\dot{H}$, with 66·84 copper protoxide, 24·06 phosphoric acid, and 9·10 water. Analyses, next page.

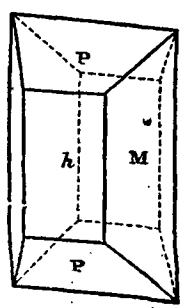
	Copper oxide.	Phospho-ric acid.	Water.	Total.	
1	65·09	24·93	9·06	99·98	Bergemann, Ehl.
2	65·74	...	8·56	...	Do. Do.
3	64·85	...	8·93	...	Do. Do.
4	66·86	23·14	10·00	100·	Hermann, Nischne-Tagilsk.
5	63·1	28·9	7·3	99·3	Rhodius, Ehl, (G. = 4·27.)

Occurs at Ehl near Rheinbreitenbach, at Nischne-Tagilsk in the Ural, and at Libethen. Hermann includes in this species Kühn's copper-diaspore (No. 10 of phosphorochalcite above), on account of its similar action before the blowpipe. No. 5 seems distinct. Compare Libethenite, No. 292 above.

295. ATACAMITE, *Jameson;* Muriate of Copper, *Phillips;* Salzkupfererz, *Werner;* Cuivre chloruré, *Dufrénoy;* Prismatoidal Habroneme-Malachite, *Mohs.*

Rhombic, ∞P 112° 45′, P̆∞ 107° 10′, the most frequent combination is ∞P . ∞P̆∞ . P̆∞ (fig. 201), in small prismatic crystals, usually combined in aggregates. It also occurs reniform and massive, with a columnar or granular structure. Cleavage, brachydiagonal perfect. H. = 3 — 3·5; G. = 4 — 4·3 (3·7, *Breithaupt*). Semitransparent or translucent on the edges; lustre vitreous; colour olive, grass or emerald-green; streak apple-green. B.B. colours the flame bluish-green, fuses, and leaves a grain of copper. In the closed tube yields water with acid reaction, and with a stronger heat a green sublimate; easily soluble in acids. Chem. com. Cu Cl + 3 Ċu + 3Ḣ, with 55·85 copper protoxide, 14·86 copper, 16·61 chlorine, and 12·68 water; or, in analysis, 74·46 copper protoxide and 17·09 hydrochloric acid. Analyses.

Fig. 201.



	Copper protox.	Muria-tic acid.	Watr.	Total.	
1	72·0	16·3	11·7	100	Klaproth, compact (cor. by *Ram.*)
2	76·5	10·5	12·5	100	Proust, Do.
3	70·5	11·5	18·0	100	Do. sandy.
4	73·0	16·2	10·8	100	J. Davy, crystallized.
5	50·00*a*	14·92*b*	21·75	100	Berthier, from Cobija.

(*a*) + 13·33 copper; (*b*) chlorine.

This mineral occurs at Remolinos, Santa Rosa, and other places in Chili, in veins in the older rocks with quartz, limonite, malachite, and other copper ores. At Tarapaca in Bolivia it is found in veins with ores of silver. It is also said to occur with the iron ore at

Schwarzenberg in Saxony. The compact variety forms a crust on some lavas, as on Etna, and especially on those of Vesuvius of A. D. 97, of 1804, 1820, and 1822. This salt often appears on copper long exposed to the atmosphere or sea water, and is the *aerugo nobilis* seen on antique bronzes. On some of these from Egypt Haidinger observed it crystalline. In South America it is used as an ore of copper, and sent as such to England.

296. VOLBORTHITE, *G. Rose.*

Hexagonal; in small tabular crystals, 0P . ∞P, either single or united in spherical groups or foliated masses. H. = 3; G. = 3·55. Colour olive-green; streak almost yellow. In the closed tube yields water, and becomes black. B.B. on charcoal fuses easily, and in a stronger heat forms a graphite-like slag, containing grains of copper. With soda is reduced to metallic copper; on platina wire with salt of phosphorus, in the inner flame, forms a green, in the outer flame a yellow glass. Soluble in hydrochloric or nitric acids. Chem. com. probably a vanadiate of copper oxide.

Found at Syssersk and Nischne-Tagilsk in Siberia, and on hausmannite at Friedericksrode in Thuringia, as a secondary production.

297. ARSENIOSIDERITE, *Dufrénoy.*

Microcrystalline, in spherical aggregates composed of easily separable fibres. Friable, and leaves a mark on paper. H. = 1 — 2; G. = 3·88 (*Rammelsberg*), 3·52 (*Dufrénoy*). Opaque; lustre metallic pearly. Colour ochre-brown, becoming darker in the air. Streak brownish-yellow. B.B. fuses easily, with reaction for iron and arsenic. Chem. com. $\dot{C}a^5\,\dddot{A}s + 3\,\dddot{F}e^2\,\dddot{A}s + 11\,\dot{H}$, with 39·0 arsenic acid, 40·7 iron peroxide, 11·9 lime, and 8·4 water. Analyses.

	Arsenic acid.	Iron perox.	Mang. perox.	Lime.	Potash.	Silica.	Water.	Total.	
1	34·26	41·31	1·29	8·43	0·76	4·04	8·75	98·84	Dufrénoy.
2	39·16	40·00	...	12·18	...	..	8·66	100	Rammelsberg.

Rammelsberg found that it contains no silica, but a minute portion of manganese in the iron. It occurs in the deposits of manganese ore at Romanêche near Mâçon in France.

298. PHARMAKOSIDERITE, *Hausmann;* Arseniate of Iron, *Phillips;* Fer arséniaté, *Hauy, Wurfelerz, Werner;* Cube ore, *Jameson;* Hexahedral Lirikon-Malachite, *Mohs.*

Tesseral, and tetrahedral-semitesseral. The crystals usually consist of the cube ∞O∞, with $\frac{O}{2}$, or with ∞O; also a trigonal dode-

cahedron approaching very near to the cube. They are mostly very small and collected in druses. Cleavage, tesseral very imperfect. Rather brittle. H. = 2·5; G. = 2·9 — 3. Semitransparent to translucent on the edges; lustre adamantine or resinous; colour olive-green, pistacio to emerald-green, honey-yellow, and brown; streak straw-yellow. Pyro-electric. In closed tube yields water, becomes red, and intumesces slightly. B.B. on charcoal fuses easily with strong arsenical odours to a steel-grey magnetic slag. Easily soluble in acids. Chem. com. according to Berzelius, $\dot{Fe}^3\ddot{A}s + \dot{Fe}^3\ddot{A}s^2 + 18\,\dot{H}$, with 40·4 arsenic acid, 28·1 iron peroxide, 12·6 iron protoxide, and 18·9 water. His analysis gave 40·20 arsenic acid, 2·53 phosphoric acid, 37·82 iron peroxide, 0·65 copper protoxide, 18·61 water, 1·76 veinstone (= 101·57).

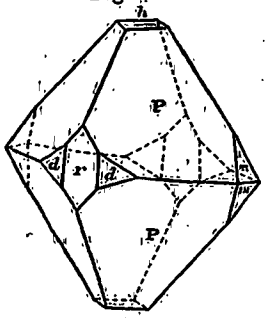
The older analyses of Vauquelin and Chevenix are imperfect. It is rather rare, but occurs in great beauty with other copper ores at Wheal Gorland, Wheal Unity, and Carharrak in Cornwall, coating cavities in quartz. Also at St Leonard in the Haute-Vienne in France; Langeborn in the Spessart; Lobenstein in Reuss; Graul near Schwarzenberg in Saxony; and in some parts of North America.

Lévy distinguished a variety from Horhausen in Nassau under the name *Beudantite*, but it agrees in crystallization, and so far as known also in composition with pharmakosiderite.

299. Scorodite, *Breithaupt*, *Phillips*, *Dufrénoy*; Peritomous Fluor-Haloid, *Mohs*.

Rhombic; the rather acute fundamental form (*P*), with polar edges 115° and 102°, generally predominates in the combinations, along with $\infty\breve{P}\infty$ and $\infty\check{P}\infty$ (*r*); sometimes also with 0P (*h*). $\infty\check{P}2$ (*d*) 119°, and $2\breve{P}\infty$ (*m*) 48° (fig. 202). The crystals are small, pyramidal, and grouped in druses. It also occurs in fine columnar, fibrous, and compact aggregates. Cleavage, prismatic along $\infty\breve{P}2$ imperfect; rather brittle; H. = 3·5 — 4; G. = 3·1 — 3·2. Translucent; lustre vitreous; colour leek-green to greenish-black, also indigo-blue, red, and brown. In closed tube yields water and becomes yellow. B.B. on charcoal fuses easily, emitting arsenic vapours, to a grey metallic and magnetic slag. Easily soluble in hydrochloric (not in nitric) acid, forming a brown solution. Chem. com.

Fig. 202.



$\dot{Fe}\ddot{A}s + 4\,\dot{H}$, with 49·8 arsenic acid, 34·6 iron peroxide, and 15·6 water. Analyses.

	Arsenic acid.	Iron perox.	Water.	Total.	
1	50·78	34·85	15·55*a*	101·85	Berzelius, Antonio Pereira, Brazil.
2	49.6	34·3	16·9*b*	101·2	Boussingault, Loaysa, Popayan.
3	50·95	31·89	15·64	98·48	Damour, Vaulry (G. = 3·11); green crystals.
4	51·06	32·74	15·68	99·48	Do. Cornwall, bluish crystals.
5	52·16	33·00	15·58	100·74	Do. Schwarzenberg, Saxony.
6	50·96	33·20	15·70	90·86	Do. Brazil (G. = 3·18).
7	48·05	36·41	15·54	100	Hermann, Nertschinsk.

(*a*) + 0·67 phosphoric acid, and trace of copper protoxide; (*b*) + 0·4 protoxide of lead.

Count Bournon named this mineral *Cupreous arseniate of iron*, Chevenix having found in it 22·5 per cent. of copper protoxide, probably an impurity, as R. Phillips showed that it contained no copper. No. 1 was named *Néoctèse* by Beudant, but agrees in form and composition with the others. Nos. 2 and 7 are amorphous varieties, the latter named an iron-sinter.

Scorodite is probably a secondary production, from the decomposition of ores containing arsenic and iron. At St Austle in Cornwall, Vaulry in France, Schlackenwald and Schönfeld in Bohemia, it occurs in veins of tin ore; at Antonio Pereira, in great beauty, in cavities and fissures in götheite or brown iron ore; and at Loaysa near Marmato in veins with gold.

300. Symplesite, *Breithaupt.*

Monoclinohedric, like gypsum, but dimensions unknown. It occurs in very fine prismatic crystals, often almost microscopic; and also in scopiform groups or masses. Cleavage in one direction very perfect. Rather sectile; H. = 2·5; G. = 2·957. Transparent or translucent; lustre vitreous, but pearly on the cleavage planes; colour pale indigo to celadine-green, with bluish-white streak. In the closed tube it yields water (25 per cent.), then arsenic acid, and becomes brown. B.B. on charcoal emits strong arsenic odours, becomes black and magnetic, but does not fuse. With fluxes shows reaction for iron and trace of manganese. Chem. com. according to Plattner, arseniate of iron protoxide with water, and also a little sulphuric acid and protoxide of manganese. It occurs with siderite at Klein-Friesa near Lobenstein in Reuss.

301. Brochantite, *Lévy, Phillips;* Prismatic Dystome Malachite, *Mohs.*

Rhombic, ∞P 117°, $\breve{P}\infty$ 150° 30′. The crystals of $\infty P \,.\, \infty\breve{P}\infty \,.\, \breve{P}\infty$, with other forms, are short prismatic, and vertically striated.

It also occurs reniform with a fine columnar structure. Cleavage imperfect. H. = 3·5 — 4; G. = 3·75 — 3·9. Transparent or translucent; lustre vitreous, but pearly on the cleavage planes; colour emerald or blackish-green; streak bright-green. In the open tube yields water and sulphurous acid. B.B. on charcoal fuses, leaving a grain of copper. Easily soluble in acids. Chem. com. $\dot{Cu}\,\ddot{S} + 3\,\dot{Cu}\,\dot{H} = 70{\cdot}28$ copper protoxide, 17·76 sulphuric acid, and 11·96 water. Analyses.

	Copper protox.	Sulphuric acid.	Water.	Tin oxide.	Lead oxide.	Total.	
1	62·63	17·13	11·89	8·18	0·03	99·86	Magnus, Rezbanya.
2	66·94	17·43	11·92	3·15	1·05	100.49	Do. Do.
3	68·34	18·69	12·97	..	...	100	No. 1 corrected, Do.
4	69·52	18·10	12·38	...	...	100	No. 2 do. Do.
5	66·2	16·6	17·2	...	...	100	Berthier, Mexico.
6	67·75	18·88	12·81	...	...	100	Forchhammer, Iceland.

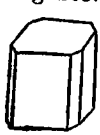
This mineral occurs in small distinct crystals on malachite at Rezbanya in Hungary, at Katharinenburg in Siberia, and at Roughtonhill in Cumberland. The oxide of tin seems accidental, and is omitted in the corrected analyses. No. 5, a sulphate of copper from Mexico, and No. 6, the *Krisuvigite* of Forchhammer, a green mineral, forming considerable beds at Krisuvig in Iceland, seem chemically identical.

Königine of Lévy, said to be rhombic, with ∞P 105°; and forming short prismatic crystals, of the combination ∞P . 0P . $\infty\breve{P}\infty$. $n\breve{P}\infty$ (*n* being a large number); cleavage, basal perfect; H. = 2; translucent; lustre vitreous; colour emerald or blackish-green; consists, according to Wollaston, of copper protoxide and sulphuric acid, perhaps with water. It occurs in the Werchoturie Mountains in Siberia, and is probably identical with brochantite.

302. VIVIANITE, *Allan*, *Dufrénoy;* Phosphate of Iron, *Phillips:* Blaueisenerde, *Werner;* Blue Iron, *Jameson;* Eisenblau, *Hausmann;* Fer phosphaté, *Hauy;* Dichromatic Euclase-Haloid, *Mohs.*

Monoclinohedric, ∞P 111°-6′, P 119° 4′, P∞ 54° 13′. The most common combination is (∞P∞) . ∞P∞ . P∞, in prismatic crystals (fig. 203), but mostly small, and attached singly or in groups. Other crystals are like those of gypsum or fig. 205, p. 372. It also forms spherical reniform masses, with a radiated columnar or fibrous texture, or occurs massive, disseminated, and earthy. Cleavage, clinodiagonal very perfect; sectile, and in thin laminæ flexible; H. = 2; G. = 2·6 — 2·7. Translucent or in thin plates transparent; lustre vitreous, cleavage faces bright pearly; colour indigo-blue to blackish-green; by trans-

Fig. 203.



mitted light, olive-green along the axis and orthodiagonal, dark Berlin-blue along the clinodiagonal; streak bluish-white, but soon becomes blue on exposure; the earthy variety is white in the beds but also changes to blue in the air; the dry crushed powder is liver-brown. In the closed tube yields much water, intumesces, and becomes spotted with grey and red; B.B. on charcoal becomes red, and then fuses to a grey, shining, magnetic granule. Easily soluble in hydrochloric or nitric acid; becomes black in warm solution of potash. Analyses.

	Phosphoric acid.	Iron prot.	Iron perox.	Watr.	Total.	
1	26·4	41·0	..	31·0	98·4	Vogel, Bodenmais.
2	31·18	41·23	...	27·48	99·88	Strömeyer, St Agnes, Cornwall.
3	26·90	42·10	...	28·50	97·50	Dufrénoy, Isle of France.
4	32·0	47·5	...	20·0	99·5	Klaproth, Eckartsberga.
5	30·32	43·77	...	25·00*a*	99·82	Brandes, Hillentrup, Lippe.
6	23·1	43·0	...	32·4 *b*	99·4	Berthier, Alleyras.
7	27·3	56·0	...	16·5	99·8	Do. Anglar.
8	26·06	46·31	...	27·14	99·51	Thomson, New Jersey.
9	24·95	48·79	...	26·26	100	Segeth, Kertsch, Crimea.
10	28·40	33·91	12·06	——	——	Rammelsberg, New Jersey.
11	——	33·98	12·06	27·49	——	Do. Do.
12	29·01	35·65	11·69	——	——	Do. Bodenmais.
13	28·60	34·52	11·91	27·49	102·52	Mean of Nos. 10, 11, 12.

(*a*) + 0·70 alumina, 0·03 silica; (*b*) + 0·6 alumina, 0·3 manganese peroxide.

The earlier analyses are imperfect, from the uncertain methods of separating the iron from the phosphoric acid, and from not distinguishing the two oxides of iron. Nos. 1, 2, 3 are the crystallized vivianite; 4, 5, 6, the earthy or blue iron. No. 7 is the *anglarite* from the Haute Vienne, 9 per cent. peroxide of manganese being rejected as accidental. No. 8 is the *Mullicite* from the Mullica Hills, 7·9 per cent. quartz being also rejected. In a mineral from the same locality, Vanuxem found nearly the same proportions as above. Nos. 10, 11 are also the mullicite, and No. 12 a crystallized variety from Bodenmais.

According to Rammelsberg, the original colourless vivianite is a hydrous phosphate of iron protoxide (isomorphous with erythrine), or $\dot{Fe}^3\,\dddot{P} + 8\,\dot{H} = 42$ iron protoxide, 29 phosphoric acid, and 29 water. But on exposure 2 atoms of this salt exchange half the water for 3 atoms oxygen, when it acquires a blue colour, with the composition $6\,(\dot{Fe}^3\,\dddot{P} + 8\,\dot{H}) + (\ddot{Fe}^3.\dddot{P}^2 + 8\,\dot{H})$, with 29·10 phosphoric acid, 33·00 iron protoxide, 12·22 iron peroxide, and 25·68 water.

Transparent, indigo-coloured, crystals, sometimes an inch in diameter and two inches long, occur with iron and copper pyrites in the tin and copper veins at St Agnes in Cornwall; other fine varieties at Bodenmais in beds of iron ore in gneiss; in the auriferous veins at Vöröspatak in Siebenburg, where it was first found, and at Allentown

and Imleytown in new Jersey. At Kertsch in the Crimea and in New Jersey, the fibrous variety fills the interior of fossil shells. In the Isle of France it occurs in lava, and also in the volcanic rocks of Sicily and Auvergne. The earthy varieties are very common, as in Cornwall, Styria, North America, Greenland, and New Zealand. It is often imbedded in clay, and in Northern Germany, Sweden, Norway, and the Zetland Isles, in peat mosses with iron ore, sometimes forming a blue crust on the dried peats, which in East Friesland are then thought of better quality. At Ballagh in the Isle of Man it incrusted fossil horns of the elk and deer, and it also occurred on the head of the rhinoceros preserved in the ice near the Wilui River in Siberia. It seems frequently a recent formation from putrid animal matter, large quantities having been found under some old slaughter houses at the foot of the Castle Rock in Edinburgh.

It is sometimes used as a pigment.

303. DUFRENITE, *Brongniart;* Grünerisenstein, *Mohs;* Green Iron Earth, *Allan.*

Microcrystalline, but probably rhombic with $\infty P = 123°$. Spherical, botryoidal, reniform masses, with a radiated fibrous texture and drusy surface. Cleavage probably brachydiagonal; very brittle. H. = 3 — 3·5; G. = 3·3 — 3·4. Translucent on the edges, or opaque; shining or dull; colour dirty or dark leek-green, pistacio or blackish-green. Streak siskin-green. Yields water in the closed tube. B.B. fuses readily to a porous, black, non-magnetic globule. Soluble in hydrochloric acid. Chem. com. $2\,\dot{F}e^2\,\ddot{P} + 5\,\dot{H}$, or 63 iron peroxide, 28 phosphoric acid, and 9 water. Analyses.

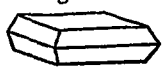
	Phosphoric acid.	Iron perox.	Manganese perox.	Water.	Total.	
1	27·72	63·45	...	8·56	99·73	Karsten, Siegen.
2	27·85	56·20	6·76	9·29	100	Vauquelin, Haute Vienne.

Green iron ores are found in many mines, as fibrous varieties in the Westerwald, at Hirschberg in Reuss, and Limoges in France; the earthy in veins in the older rocks, and with limonite ores, as at Elbingerode in the Harz, in Saxony, Bavaria, and Hungary. Many of them seem merely mixtures, often of limonite, the earthy varieties of which frequently contain phosphoric acid. In No. 2 part of the iron is replaced by manganese peroxide, and it has been named *alluaudite*, but is not distinct.

304. URANITE, *Jameson, Phillips;* Lime Uranite, *Naumann;* Uran-mica, Uranglimmer, *Werner;* Urane oxydé, *Hauy;* Pyramidal Euchlore Malachite, *Mohs.*

Tetragonal; P 143°. The crystals almost always tabular, through predominance of 0P, and bounded on the sides by ∞P, P (fig 204) or occasionally by other forms, are attached singly or united in small druses. Cleavage, basal very perfect; sectile; H. = 1 — 2; G. = 3 — 3·2. Translucent; pearly on 0P; colour siskin-green to sulphur-yellow. Streak yellow. In the closed tube yields water and becomes yellow; B.B. on charcoal fuses to a black mass with semi-crystalline surface; with soda forms a yellow infusible slag. In nitric acid forms a yellow solution. Chem. com. essentially $\dot{Ca}^2\,\ddot{\dot{P}} + \ddot{U}^4\,\ddot{\dot{P}} + 16\,\dot{H}$, with 15·5 phosphoric acid, 62·6 uranium peroxide, 6·2 lime, and 15·7 water. Analyses.

Fig. 204.



	Phosph. acid.	Uran. perox.	Lime.	Baryta.	Tin oxide.	Watr.	Total.	
1	15·20	61·73	5·88	1·57	0·06*a*	15·48	100·12	Berzelius, Autun.
2	14·5	55·0	4 6	...	...*b*	21·0	99·1	Laugier, Do.

(*a*) + 0·20 magnesia and manganese protoxide; (*b*) + 3·0 silica and iron peroxide.

Uranite occurs, though rarely, in veins and beds with various ores, as at Johann-Georgenstadt, and Eibenstock in Saxony, and of great beauty in granite at St Symphorien near Autun, and St Yrieux near Limoges in France. Also at Chesterfield in Massachusetts, and on Wolf island in lake Onega.

305. CHALCOLITE, *Werner, Phillips;* Copperuranite, Kupferuranite, *Naumann.*

Tetragonal and isomorphous with uranite; but the crystals are more acute in the edges. Cleavage, basal very perfect. Rather brittle; H. = 2 — 2·5; G. = 3·5 — 3·6. Translucent; pearly on 0P. Colour grass to emerald or verdigris-green. Streak apple-green. B.B. acts like uranite; but on charcoal with soda yields a grain of copper, and with salt of phosphorus and a little tin also shows reaction for copper. Moistened with hydrochloric acid, it colours the flame blue. In nitric acid forms a yellowish-green solution. Boiled in solution of soda it becomes brown. Chem. com. $\dot{Cu}^2\,\ddot{\dot{P}} + \ddot{U}^4\,\ddot{\dot{P}} + 16\,\dot{H}$ = 15·2 phosphoric acid, 61·1 uranium peroxide, 8·4 copper protoxide, and 15·3 water. Analyses, next page.

In chemical composition this mineral only differs from uranite in containing copper protoxide instead of lime. If we consider these as

	Phosphoric acid.	Uranium. perox.	Copper protox.	Watr.	Total.	
1		74·1	8·3	15·4	97·8	Gregor, Cornwall.
2	16·0	60·0	9·0	14·5	99·5	R. Phillips, Do.
3	15·57	61·39	8·44	15·05	100·45	Berzelius, Do.

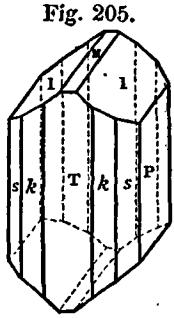
isomorphous with the uranium peroxide, the formula for both minerals may be given as $[\dot{C}a\ (\dot{C}u) + \ddot{U}^2]\ \ddot{P} + 8\ \dot{H}$.

Chalcolite occurs in veins in the crystalline schists or in granite, as at Johann-Georgenstadt, Eibenstock, and Schneeberg in Saxony; Michaelsberg in Bohemia; Bodenmais in Bavaria; near Baltimore in North America; and in fine varieties near Redruth and St Austle in Cornwall.

306. ERYTHRINE, *Beudant;* COBALT-BLOOM, *Phillips;* Kobalt-blüthe, *Hausmann;* Rother Erdkobold, *Werner;* Cobalt arseniaté, *Hauy;* Diatomous Euclase-Haloid, *Mohs.*

Monoclinohedric; usual combination $(\infty P\infty)$ (*P*) . $\infty P\infty$ (*T*) . $P\infty$ (*M*), forming rectangular prisms, terminated by an oblique plane (*M*) (like fig. 203 above, with $M : T = 55° 9'$); $\infty P3$ (*k*) = 130° 10′, and P (*l*) 118° 23′, are often added (fig. 205). Cleavage, clinodiagonal (*P*) very perfect. Rather sectile, in thin laminæ slightly flexible. H. = 2·5; G. = 2·9 — 3. Translucent; lustre vitreous, but pearly on the cleavage planes; colour crimson, or peach-blossom red, rarely pearl-grey, or dirty-green when decomposed. In the closed tube it yields water and becomes blue; or, when it contains iron, green and brown. B.B. on charcoal in the inner flame fuses, emitting arsenical fumes, to a grey globule of arsenite of cobalt; colours borax blue. It is easily soluble in acids; and when digested in solution of potash becomes black. Chem. com. according to Kersten, $\dot{C}o^3\ \ddot{A}s + 8\ \dot{H}$, with 24 water, 38·5 arsenic acid, and 37·5 cobalt protoxide, part of the latter being often replaced by lime or the protoxides of iron and nickel. Analyses, next page.

Fig. 205.



Erythrine occurs in veins or beds with other cobalt ores, the crystallized or foliated variety especially at Schneeberg and Annaberg in the Erzgebirge. The earthy is more common at the above and other places in Saxony, in Bohemia, Thuringia, the Harz, St Jean in the

	Arsenic acid.	Cobalt protox.	Nickel protox.	Iron prot.	Lime.	Water.	Arsenious acid.	Total.	
1	37	39	...	...	...	22	...	98	Bucholz, Ricchelsdorf.
2	40·0	20·5	9·2	6 1*a*	..	24·5	...	100·3	Laugier, Allemont.
3	38·43	36·52	trace	1·01	...	24·10	...	100·6	Kersten, Schneeberg.
4	38·30	33·42	...	4·01	...	24·08	...	99·81	Do. Do. G. = 2.912.
5	38·10	29·19	...	...	8·00	23·90	...	99·19	Do. Do.
6	19·10	16·60	trace	2·10	trace	11·90	51·00	100·70	Do. Do.
7	20·00	18·30	trace	...	trace	12·13	48·10	98·53	Do. Annaberg.

(*a*) Peroxide.

Pyrenees, and Modum in Norway. It is also found in Cornwall, in the lead mines of Alston in Cumberland, at Alva in Stirlingshire, and Tyndrum in Perthshire in Scotland. It is used in preparing blue colours.

The *Kobaltbeschlag*, or Earthy-encrusting-cobalt, which forms peach-blossom or rose-red reniform or spheroidal masses, is, according to Kersten (Nos. 6, 7), a mixture of erythrine with arsenious acid, which is extracted by hot water.

Lavendulan of Breithaupt, forms thin reniform crusts of a lavender-blue colour, translucent, and resinous or vitreous. H. = 2·5 — 3; G. = 2·95 — 3·1. In the closed tube it yields water. B.B. fuses very easily, colouring the outer flame blue; on charcoal emits odours of arsenic. According to Plattner, it consists of arsenic acid, protoxides of cobalt, nickel and copper, and water. It occurs very rarely in one of the mines at Annaberg.

307. NICKELINE, *Beudant;* Nickel-ochre, *Phillips;* Nickel-green, *Dana;* Nickelblüthe, *Hausmann;* Nikkelokker, *Werner;* Nickel arseniaté, *Hauy.*

Microcrystalline (triclinohedric? *Hausmann*); it occurs in short capillary crystals and flaky efflorescences; also massive and disseminated. Texture earthy, rather sectile; H. = 2 — 2·5; G. = 3 — 3·1. Lustre dull or glistening. Colour apple-green or greenish-white; streak greenish-white and shining. In closed tube yields water. B.B. on charcoal emits arsenical vapours, and fuses with reaction for nickel. Easily soluble in acids. Chem. com. $\dot{N}i^3\ddot{A}s + 8\dot{H}$, with 38·4 arsenic acid, 37·6 nickel protoxide, and 24 water. Analyses, next page.

This mineral seems a recent production arising in the decomposition of various ores containing arsenic and nickel. It is found in many mines, as at Andreasberg in the Harz, Annaberg in Saxony, Saalfeld in Thuringia, Joachimsthal in Bohemia, and the Leadhills

	Arsenic acid.	Sulphuric acid.	Nickel oxide.	Cobalt oxide.	Iron prot oxide.	Watr.	Total.	
1	36·97	0·23	37·35*a*	...	1·13*b*	24·32	100	Stromeyer, Riechelsdorf.
2	36·8	...	36·2	2·5	...	25·5	100	Berthier, Allemont, Dauphiné.
3	38.30	...	36·20	1·53	trace	21·91	99·94	Kersten, Schneeberg.
4	38·90	...	35·00	...	2·21	24·02	100·13	Do. Do.
5	37·21	0·52*c*	36·10	trace	1·10	23·92	98·85	Do. Do.

(*a*) With cobalt protoxide; (*b*) peroxide; (*c*) arsenious acid.

in Scotland. At Riechelsdorf in Hessia it is used in preparing blue colours.

III. Family.—Lead-Salts.

308. Cerussite, *Haidinger;* Cerusse, *Beudant;* Carbonate of Lead, *Phillips;* Lead Spar, *Jameson;* Weissbleierz, *Werner;* Plomb carbonaté, *Hauy;* Diprismatic Lead Baryte, *Mohs.*

Rhombic; isomorphous with arragonite and nitre; ∞P (*M*) 117° 14′, $\breve{P}\infty$ (*P*) 108° 13′, $2\breve{P}\infty$ (*u*) 69° 18′. Other important simple forms are 0P, P (*t*), $\frac{1}{2}\breve{P}\infty$ (*s*), $4\breve{P}\infty$, $\infty\breve{P}\infty$ (*l*), $\infty\breve{P}3$ (*e*) and some of the most common combinations P . $2\breve{P}\infty$, P . $\infty\breve{P}\infty$. $\infty P, \breve{P}\infty$. $2\breve{P}\infty$. $4\breve{P}\infty$. $\infty\breve{P}\infty$. P . ∞P (figs. 206, 207). The second figure, from Mohs, is placed in an opposite position from that adopted above after Naumann. The crystals appear partly pyramidal, partly horizontal,

Fig. 206.

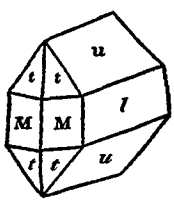


Fig. 207.

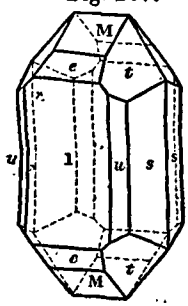
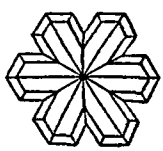


Fig. 208.



or seldom vertical, prismatic, partly tabular, the brachydoms (*u*) horizontally striated. Macles are very common combined by a plane of ∞P, and either merely in contact or intersecting. Sometimes three

crystals are combined in a stellated group (fig. 208). The crystals are attached singly or united in druses, or form diverging and plumose groups. It also occurs fine granular or earthy. Cleavage, prismatic along ∞P, also brachydomatic along 2P̆∞, both rather distinct. Fracture conchoidal; brittle and easily frangible; H. = 3 — 3·5; G. = 6·4 — 6·6 (earthy varieties only 5·4). Transparent or translucent; lustre adamantine or resinous; colourless and often white, but also grey, yellow, brown, black, rarely green, blue, or red. Streak white. B.B. decrepitates violently, becomes yellow, loses its carbonic acid, and acts like protoxide of lead. Wholly soluble with effervescence in nitric acid; and also in solution of potash. Chem. com. Ṗb C̈, with 83·6 protoxide of lead and 16·4 carbonic acid. Analyses.

	Lead prot.	Carb. acid.	Alumina and iron peroxide.	Carbon.	Total.	
1	82	16	2	...	100	Klaproth, Leadhills.
2	79	18	...	2	99	Lampadius (dark variety, Bleischwärtze).
3	83·51	16·49	...	...	100	Bergemann, Griesberg, Eifel.
4	84·5	15·5	...	...	100	John, Nertschinsk (transparent).
5	73·50	15·00	2·66	8·00*a*	99·16	Do. Do. (translucent).

(*a*) = silica.

Thomson found the cerussite from Leadhills to be pure carbonate of lead with a mere trace of water. A variety from Monte Poni near Iglesias in Sardinia, with G. = 5·9, examined by Kersten, contained 92·10 carbonate of lead and 7·02 carbonate of zinc oxide. In another from the Charente department, Berthier found $\frac{1}{16}$ per cent. carbonate of silver; and some Harz specimens also contain silver.

The red earthy lead ore (*Bleierde*) from Kall in the Eifel seems a mere mixture; and contains according to Bergemann 94·23 carbonate of lead, 2·57 water, 1·07 quartz, 2·2 peroxide of iron and alumina.

Cerussite is a very common ore of lead occurring especially in beds or veins with galena. It is most abundant in the higher parts of the veins where the galena has begun to decompose, and is probably produced, as Hausmann suggests, by the sulphuric acid, then set free, acting on calc-spar, whose carbonic acid combines with the protoxide of lead. The more remarkable varieties occur at Przibram, Mies, and Bleistadt in Bohemia, Bleiberg in Carinthia, Rezbanya in Hungary, Zschopau and Johanngeorgenstadt in Saxony, Zellerfeld, Tanne, Andreasberg and Klausthal in the Harz; in England in Devonshire and Cornwall, especially at the St Minver's mine in snow-white crystals of such extreme delicacy as almost to preclude the possibility of transport; also at Alston Moor and Keswick; in Scotland at Lead-

hills and Wanlockhead, where stalactitic and stellated varieties are common. Fine varieties likewise occur in France, Tyrol, Siberia (Nertschinsk), the United States (Wythe County in Virginia, Davidson's County in N. Carolina), and other places. The earthy lead-spar, as it is called, is common in most of the above localities, and also in Poland and Silesia; and opaque pseudomorphs in the form of sulphate of lead occur at Leadhills.

Where abundant this mineral is used as an ore of lead.

309. ANGLESITE, *Beudant;* Sulphate of Lead, *Phillips;* Plomb sulphaté, *Hauy;* Bleivitriol, *Hausmann;* Vitriolbleierz, *Werner;* Prismatic Lead Baryte, *Mohs.*

Rhombic, ∞P 103° 38′, $\breve{P}\infty$ 75° 29′, $\frac{1}{2}\bar{P}\infty$ 101° 15′, and many other forms. The combinations are generally very complex, the more common being $\frac{1}{2}\bar{P}\infty . \infty P$, $\frac{1}{2}\bar{P}\infty . \infty P$, $\breve{P}\infty . 0P$, with others in which P and $\frac{3}{4}\bar{P}\frac{3}{2}$ more or less prevail. The crystals (fig. 209) sometimes short prismatic, at other times pyramidal, or tabular from 0P, are usually small, and attached singly or combined in druses. Cleavage, prismatic along ∞P and basal, but neither very perfect. Fracture conchoidal; very brittle; H. = 3; G. = 6·2 — 6·3. Transparent or translucent; lustre adamantine or resinous; colourless and white, but occasionally coloured yellow, grey, brown, or blue; streak white. B.B. in the closed tube decrepitates; on charcoal fuses in the oxidating flame to a clear bead, which becomes milk-white when cold; in the reducing flame yields lead; with soda and silica shows the reaction for sulphur; very difficultly soluble in acids, but wholly in solution of potash. Chem. com. $\dot{P}b\ddot{S}$, with 78·7 lead protoxide and 26·3 sulphuric acid. Analyses.

Fig. 209.

	Lead protox	Sulph. acid.	Iron perox.	Manga. perox.	Watr.	Total.	
1	71·0	24 8	1·0	...	2·0	98·8	Klaproth, Anglesea.
2	70·50	25·75	...	...	2·25	98·50	Do. Wanlockhead.
3	72·47	26·09	0·09*a*	0·16*b*	0·12	99·35	Stromeyer, Zellerfeld.

(*a*) Hydrous peroxide; (*b*) with trace of alumina + 0·51 silica.

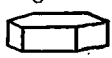
This mineral occurs with other lead ores principally in the older rocks. Fine varieties are found at Pary's Mine in Anglesea and in Cornwall, also at Zellerfeld, Clausthal, and Tanne in the Harz, at Badenweiler in Baden, in Siegen, Silesia, and other parts of Germany; Southampton in Massachusets, Rossie in New York, and the Missouri mines in North America, also furnish good specimens. At Leadhills

and Wanlockhead transparent tabular crystals some inches in diameter are common, and it also occurs in the interior or on the surface of cubical crystals of galena, from whose decomposition it is probably derived. Thomson, in a specimen from Wanlockhead, found only the pure sulphate of lead with a trace of water. The compact varieties or *Bleiglas* of the Germans are common at Alston Moor in Cumberland, in Andalusia in Spain, and in Siberia. John found a blue variety from Linares in Spain, coloured by copper; and 100 lbs. of that from Zellerfeld in the Harz yielded on cupellation $\frac{3}{8}$ ounce (loth), and the same quantity of English anglesite $\frac{1}{4}$ ounce of silver.

310. LEADHILLITE, *Beudant;* Sulphato-tri-carbonate of Lead, *Brooke, Phillips;* Bleisulphotricarbonat, *Rammelsberg;* Axotomous Lead Baryte, *Mohs.*

Monoclinohedric, C = 89° 31′, ∞P 59° 40′, P 72° 10′, —P 72° 36′, 2P∞ (inclined to 0P at 111° 11′), —2P∞ (to 0P 112° 0′), and many other forms. The simplest combinations are 0P . ∞P . ∞P∞ (fig. 210), and 0P . P . —P . ∞P . P∞ . ∞P∞; but others far more complex occur, and often resemble hexagonal forms. The crystals are mostly tabular; macles, especially of three crystals, occur united by a face of ∞P3. These threefold macles closely resemble a rhombohedric combination, but may be distinguished by their base being divided into three planes inclined to each other at 179° 10′. It also forms foliated aggregates. Cleavage, basal very perfect. Slightly brittle. H. = 2·5; G. = 6·2 — 6·4 (6·0, Thomson). Transparent or translucent; lustre resinous, or adamantine-pearly on 0P; colour yellowish-white, inclining to grey, green, yellow, or brown. B.B. on charcoal intumesces, and becomes yellow, but again white when cold, and is easily reduced to metallic lead. Soluble with effervescence in nitric acid, leaving sulphate of lead. Chem. com. 3 $\dot{P}b\,\ddot{C} + \dot{P}b\,\ddot{S}$, with 72·6 of the carbonate and 27·4 of the sulphate of lead. Analyses.

Fig. 210.



	Sulphate of lead.	Carbonate of lead.			
1.	27·5	72·5	=	100	Brooke, Leadhills.
2.	28·7	71·0	=	99·7	Berzelius, Do.
3.	27·3	72·7	=	100	Stromeyer, Do.
4.	27·43	72.57	=	100	Thomson, Do.

This mineral occurs at Leadhills in Scotland, in crystals an inch or less in diameter. The pearly lustre on 0P is one of its most characteristic marks. It is also said to occur in Grenada in Spain, and on the Greek island of Serpho in a bed of limonite in mica slate.

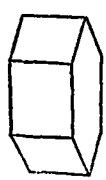
311. LANARKITE, *Beudant;* Sulphato-carbonate of Lead, *Phillips;* Bleisulphocarbonat, *Rammelsberg;* Prismatoidal Lead Baryte, *Mohs.*

Monoclinohedric; usual combination 0P . P∞ . ∞P (with 0P : P∞ 120° 45′); the crystals, lengthened prismatically along the orthodiagonal, are indistinct. Cleavage, basal very perfect, hemidomatic along P∞ imperfect; sectile, and in thin laminæ flexible. Very easily frangible (*Breithaupt*). H. = 2 — 2·5; G. = 6·8 — 7 (*Brooke*), (6·3197, *Thomson*). Transparent; lustre resinous or adamantine, on 0P pearly; colour greenish or yellowish-white, inclining to grey. Streak white. B.B. on charcoal fuses to a white globule containing some metallic lead. Partially soluble in nitric acid with effervescence. Chem. com. Ṗb S̈ + Ṗb C̈, with 53·15 sulphate and 46·85 carbonate of lead. Brooke found 53·1 sulphate, 46·9 carbonate; Thomson, 53·96 sulphate and 46·04 carbonate of lead. The only certain locality is the Leadhills in Scotland. A compact variety is said to occur in Siberia; and both this and the former species are reported to occur at Giepenbach near Tanne in the Harz.

312. CALEDONITE, *Beudant;* Cupreous Sulphato-Carbonate of Lead, *Brooke, Phillips;* Paratomous Lead-Baryte, *Mohs.*

Rhombic P̄∞ 95°, ∞P 109°, usual combination ∞P̆∞ . ∞P̄∞ . P̄∞ (fig. 211); the crystals long prismatic, large and distinct; also acicular, and grouped in radiating tufts. Cleavage, domatic along P̄∞, brachydiagonal and macrodiagonal all imperfect; H. = 2·5 — 3; G. = 6·4. Transparent or translucent; lustre resinous; colour verdigris to mountain-green; streak greenish-white. B.B. on charcoal easily reduced to lead. Soluble in nitric acid, leaving sulphate of lead. The solution is greenish, and shows reaction for lead and copper. Chem. com., according to von Kobell, 3 Ṗb S̈ + 2 Ṗb C̈ + Ċu C̈, but Thomson thinks that the copper does not form a carbonate. Analyses.

Fig. 211.



	Sulph. of lead.	Carbon. of lead.	Copper protox.	Watr. &c.	Total.	
1	55·8	32·8	11·4*a*	...	100	Brooke, Leadhills (G. = 6·4 nearly).
2	52·88	31·91	13·37	1·84	100	Thomson, Do. (G. = 5·0).

(*a*) Carbonate.

Found at Leadhills, though very rarely, and at first taken for malachite. It is also said to occur near Tanne in the Harz with lanarkite and leadhillite.

313. LINARITE, *Brooke;* Cupreous Sulphate of Lead, *Phillips;* Bleilasur, *Breithaupt;* Diplogene Lasur-Malachite, *Mohs.*

Monoclinohedric, ∞P 61° 0′, P∞ 77° 15′, —P∞ 74° 25′, C = 84° 15′. The crystals, generally prismatic in the direction of the orthodiagonal, are formed predominantly by ∞P∞ . 0P, and the above or other hemidomes, and bounded by (∞P∞) and ∞P. Macles united by ∞P∞. Cleavage, orthodiagonal very perfect, and hemidomatic along P∞ less so. Fracture conchoidal. H. = 2·5 — 3; G. = 5·3 — 5·45. Translucent; lustre adamantine; colour azure-blue; streak pale-blue. Chem. com. $\dot{P}b\,\dot{S} + \dot{C}u\,\dot{H}$ = 75·7 sulphate of lead, 19·8 copper protoxide, and 4·5 water. Analyses.

	Sulph. of lead.	Copper protox.	Watr.	Total.	
1	75·4	18·0	4·7	98·1	Brooke, Wanlockhead.
2	74·8	19·7	5·5	100	Thomson, Do. (G. = 5·2137).

This mineral occurs in cavities with some of the previous species at Leadhills, but is rare. It is also said to occur at Linares in Spain, and perhaps in Cumberland.

314. PHOSGENITE, *Breithaupt;* Corneous Lead, *Jameson;* Muriocarbonate of Lead, *Phillips;* Plomb chloro-carbonaté, *Dufrénoy;* Hornblei, *Hausmann;* Orthotomous Lead Baryte, *Mohs.*

Tetragonal, P 94° 38′. The crystals usually formed of ∞P, 0P, with ∞P∞, and subordinate faces of P or 2P∞, are prismatic and small. Cleavage, prismatic along ∞P rather perfect. Fracture conchoidal. H. = 2·5 — 3; G. = 6 — 6·2. Transparent or translucent; lustre resinous adamantine; colour white, yellowish, greenish, or greyish-white, to wine-yellow, asparagus-green, or grey. B.B. fuses easily in the outer flame to an opaque yellow globule, becoming citron-yellow or white with a crystalline surface on cooling. In the inner flame evolves acid vapours, and is reduced to lead. Soluble with effervescence in nitric acid. Chem. com. Pb Cl + $\dot{P}b\,\dot{C}$, with 51 chloride and 49 carbonate of lead, or 79·22 protoxide of lead, 12·93 hydrochloric acid, and 7·85 carbonic acid. Klaproth found in a specimen from Matlock, 85·5 protoxide of lead, 6·0 carbonic acid, and 8·5 muriatic acid (= 100); but, as Berzelius observed, the analysis was wrong calculated, and the muriatic acid should be 14·0 (total = 105·5) (*Rammelsberg*).

This is a very rare mineral, being chiefly found at Matlock in Derbyshire, with cerussite and heavy spar. Badenweiler in Baden, Southampton in Massachusets, and Vesuvius, are other localities where it is reported to occur.

315. MENDIPITE, *Breithaupt;* Muriate of Lead, *Phillips;* Plomb chloruré, *Dufrénoy;* Berzelite, *Lévy;* Cerasite, *Dana;* Peritomous Lead-Baryte, *Mohs.*

Rhombic, but chiefly massive in crystalline or thin-columnar aggregates. Cleavage, prismatic along ∞P 102° 27′, highly perfect. Fracture conchoidal or uneven. H. = 2·5 — 3; G. = 7·0 — 7·1. Translucent; lustre adamantine-pearly on the cleavage faces; colour yellowish-white to straw-yellow and pale red; streak white. B.B. decrepitates, fuses easily, and becomes more yellow. On charcoal yields lead and acid vapours. With salt of phosphorus and copper oxide colours the flame blue. Easily soluble in nitric acid. Chem. com. Pb Cl + 2 Pb, or 40 chloride and 60 protoxide of lead = 85·8 lead, 9·78 chlorine, and 4·42 oxygen. Analyses.

	Lead protox.	Muriatic acid.	Carbonic acid.	Water.	Silica.	Total.	
1	90·20	6·54	2·63	0·63	...	100	Berzelius, Churchill.
2	90·13	6·84	1·03	0·54	1·46	100	Do.
3	76·93	8·46*a*	15·00*b*	0·63	...	101·82	No. 1 corrected, *Rammelsberg.*
	Lead.	Chlorine.	Oxygen.				
4	85·53	10·15	4·32	...	...	100	No. 1 by *Rammelsberg.*
5	85·69	9·87	4·44	...	...	100	Schnabel, Brilon.

(*a*) Chlorine; (*b*) carbonate of lead.

No. 3 is corrected according to the new atomic numbers, the lead being somewhat deficient from the method of its determination.

It is found at Churchill in the Mendip hills in Somersetshire, on black earthy manganese, and in the Kunibert mine near Brilon in Westphalia. This rare mineral is said also to occur in Cornwall, at Caldbeck near Keswick, and on the lava of Vesuvius; but the specimens from the latter place are very indistinct.

316. COTUNNITE, *von Kobell;* Cotunnia, *Monticelli.*

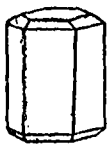
Rhombic, ∞P 118°, in small acicular crystals and semifused masses. Transparent, lustre adamantine, colour white. Easily scratched with the knife. G. = 5·238. In closed tube fuses and then sublimes, the fused mass being yellow when warm. B.B. on charcoal fuses easily, colours the flame blue, volatilizes as a white vapour, forms a white ring, and leaves a very little metallic lead. Soluble in a large amount of water. Chem. com. Pb Cl, with 74 lead and 26 chlorine.

Observed by Monticelli and Covelli in the crater of Vesuvius after the eruption of 1822.

317. PYROMORPHITE, *Hausmann;* Phosphate of lead, *Phillips;* Grün and Braunbleierz, *Werner* in part; Plomb phosphaté, *Hauy*; Rhombohedric Lead-baryte, *Mohs.*

Hexagonal, P 80° 44′. Usual combination, ∞P. 0P, often with ∞P2, rarely with P or other pyramids (fig. 212), forming prismatic crystals occasionally thicker in the middle, or spindle-shaped. The basis, 0P, is often rough or hollow. The crystals are generally united in druses, or it forms reniform, botryoidal, and massive aggregates. Cleavage, pyramidal along P very imperfect; prismatic along ∞P in traces. Fracture conchoidal or uneven. H. = 3·5 — 4; G. = 6·9 — 7. Translucent; lustre resinous or partly vitreous; colourless, but generally coloured grass, pistacio, olive, or siskin-green, and clove or hair-brown. B.B. fuses easily, and on cooling forms, with a transitory ignition, a polyhedric crystalline granule. With boracic acid and iron wire, forms phosphate of iron and lead, the latter remaining fluid after the former has become solid. Yields lead with soda. Soluble in nitric acid and in solution of potash. Chem. com. $3Pb^3 \dddot{P} + Pb\,Cl$, with 89·7 phosphate of protoxide of lead and 10·3 chloride of lead, but the phosphoric acid is often partly replaced by arsenic acid, the protoxide of lead by lime, and the chloride of lead by fluoride of calcium. Analyses.

Fig. 212.



	Phosphate of lead.	Chloride of lead.	Arseniate of lead.	Phosphate of lime.	Fluoride of calcium	Iron protoxide.	Total.	
1	89·94	10·05	...	...	...	...	99·99	Wöhler, Zschopau, green.
2	80·37	10·09	9·01	...	...	...	99·47	Do. Do. white.
3	88·16	9·91	trace	...	...	...	98·07	Do. Leadhills, orange-red.
4	77·02	10·84	...	11·05	1·09	...	100	Kersten, Freiberg, brown.
5	81·65	10·64	...	7·46	0·25	...	100	Do. Mies, botryoidal.
6	89·27	9·68	...	0·85	0·22	...	100	Do. Do. crystallized.
7	89·17	9·92	...	0·77	0·14	...	100	Do. Bleistadt, do.
8	89·11	10·07	...	0·68	0·13	...	99·99	Do. Rugland, do.
9	89·91	10·09	...	...	...	...	100	Do. Poullaouen, do.
10	89·93	10·07	...	...	...	...	100	Do. Do. massive.
11	88·42	10·25	...	...	...	1·33	100	Thomson, Leadhills.
12	92·55	7·45	...	...	...	...	100	Bergemann, Eifel, green.
13	87·38	10·23	...	0·86	0·07	0·77*a*	99·31	Lerch, Bleist. brown, G. 6·843.
14	88·42	9·57	...	1·58	0·20	0·50*a*	100·27	Do. Do. do. do.

(*a*) Phosphate.

Pyromorphite generally occurs in veins, and almost constantly associated with galena, and also with other lead ores, especially the cerussite. It is most abundant in the upper parts of the veins, and, in some cases, seems a recent produce from the galena. In some veins, the latter forms the centre, followed by the pyromorphite, and this by crocoisite on the exterior.

The finest varieties are found in the Bohemian mines of Przibram,

(green and yellow); Mies (green and brown); and Bleistadt (white and brown); and at Zschopau in Saxony; less beautiful in the Breisgau, Clausthal in the Harz, Poullaouen in Brittany, and other parts of France, Beresow in Siberia, in Mexico, and other countries. It also occurs in Cornwall and various parts of England, at Wicklow in Ireland, and at the Leadhills in Scotland. At the latter it is found in hexagonal prisms, or more often in rosettes and cauliflower-like groups or crusts. No. 11 is a mean of analyses of five specimens, with G. = 6·5781 — 6·70016, none of them containing any phosphate of lime. A light greenish-yellow specimen, with slaty texture, and G. = 5·366, contained 15 per cent. phosphate of lime; another dark-green and botryoidal, G. = 5·970, yielded 9 per cent. A variety of a beautiful orange-colour with no red in it, is also abundant at Wanlockhead, and contains 2 per cent. chromate of lead, but otherwise agrees with the green varieties, *Thomson*. In the yellowish-green pyromorphite from Beresow, G. Rose also found chrome both as the acid and oxide.

Miesite and *Polysphaerite* of Breithaupt, Nos. 4, 5, are brown, reniform or botryoidal varieties, containing more lime, and with a lower specific gravity (miesite, 6·4; polysphaerite, 5·9 — 6·1). The *Nussierite*, from Nussière, near Beaujeu, is a yellowish, greenish, or white mineral, G. = 5·04, very like the pyromorphite, and containing the same elements in somewhat different proportions. Barruel's analysis gave 46·50 lead protoxide, 19·80 phosphoric acid, 4·06 arsenic acid, 7·65 chloride of lead, 12·30 lime, 2·44 iron protoxide 7·20 silica (= 99·55).

318. MIMETESITE, *Breithaupt;* Arseniate of Lead, *Phillips;* Mimetene, *Dana;* Grünbleierz, *Werner;* Plomb arseniaté, *Hauy;* Brachytype Lead-Baryte, *Mohs.*

Hexagonal; P 81° 47′; usual combination ∞P . 0P . P, or P . 0P, sometimes also with ∞P2, 2P̆, ½P. The crystals are short prismatic, tabular, or pyramidal, forming rosettes and other groups. Cleavage, pyramidal along P, rather distinct, prismatic along ∞P, very imperfect. Fracture conchoidal or uneven; H. = 3·5 — 4·0; G. = 7·19 — 7·25. Translucent; colourless, but usually coloured honey or wax-yellow, yellowish-green, or grey. B.B. on charcoal fusible, but less easily than pyromorphite, and yields a grain of lead with strong arsenious vapours. Fused in the forceps, it crystallizes on cooling. With the fluxes acts like lead protoxide. Soluble in nitric acid and solution of potash. Chem. com. $3\,\dot{P}b^3\,\dddot{A}s + Pb\,Cl$, with 90·7 arseniate and 9·3 chloride of lime; but part of the arsenic acid occasionally replaced by phosphoric acid.

Rather rare, but occurs especially at Johann-Georgenstadt; also at Zinnwald, Badenweiler, St Prix in France, Nertschinsk in Siberia, and massive and botryoidal in Mexico. Fine crystals are found in Wheal Alfred and Wheal Unity mines near Redruth in Cornwall, at Caldbeckfell in Cumberland, and Beeralston in Devonshire.

The *Kampylite* of Breithaupt, forming orange-yellow, hexagonal prisms expanded in the middle, with G. = 6·8 — 6·9, has essentially the same composition with mimetesite, but contains phosphate of lime and traces of chromate of lead. It occurs at Alston in Cumberland and at Badenweiler.

HEDYPHANE of *Breithaupt* occurs in small crystalline masses with an imperfect cleavage along an hexagonal pyramid. Fracture conchoidal; H. = 3·5 — 4; G. = 5·4 — 5·5. Translucent; lustre resinous adamantine; colour white. B.B. when the arseniate of lead predominates, the phosphate is not wholly reduced, but remains as a fused crystalline bead; the occurrence of arsenic may be known from its odour when heated. Chem. com. (analysis No. 2) similar to the mimetesite, but a large part of the protoxide of lead replaced by lime. It occurs at Langbanshytta in Sweden. Analyses.

	Arseniate of lead.	Phosphate of lead.	Chloride of lead.	Arseniate of lime.	Phosphate of lime.	Total.	
1	82·74	7·50	9·69	...	...	99·84	Wöhler, Johann-Georgenstadt.
2	60·10	...	10·29	12·98	15·51	98·88	Kersten, Langbanshytta.

No. 1 is mimetesite, No. 2 hedyphane; in a variety of the former from Wheal Unity, Gregor found 69·76 lead protoxide, 2640 arsenic acid, and 1·58 muriatic acid.

Pyromorphite and mimetesite may, in a more general point of view, be regarded as one species, and Weiss conjoins them under the name of Buntbleierz. Mohs formerly also united them, but in the last edition of the Anfangsgrunde they are again separated.

319. BLEINIERITE, *N.*; Bleiniere, *Hausmann*; Arséniate de plomb terreux, *Beudant.*

Amorphous, in reniform spheroidal masses, often with a curved lamellar division; also occurs earthy, disseminated, or encrusting. H. = 4, G. = 3·933 (*Karsten*), 4·60 — 4·76 (*Hermann*). Opaque; lustre dull resinous, or earthy; colour grey or brown to brownish-red, yellow or yellowish-white, sometimes veined or clouded. Streak greyish or yellowish-white. In the closed tube it yields water and becomes darker. B.B. on charcoal is reduced to a grain of metal, which when ignited gives out antimony fumes and leaves lead. Some varieties evolve arsenious odours. Chem. com. $\dot{P}b^3\ddot{S}b + 4\dot{H}$ by

Hermann's analysis, which gave 61·83 protoxide of lead, 31·71 antimonic acid, and 6·46 water (= 100). It was formerly analyzed by Bindheim, who overlooked the antimony, and by Pfaff, who found 33·10 protoxide of lead, 43·96 antimonious acid, 16·42 arsenic acid, 3·24 copper protoxide, 0·24 iron peroxide, 2·34 silica, 062 sulphuric acid, and 3·32 of iron, manganese, and some unknown substance (= 103·23). This was evidently a mere mixture of various decomposed ores. Hausmann finds that many bleinierites contain arsenic as well as antimonic acid, as is shown by their action B.B. This mineral seems a product of the decomposition of other lead ores. Its only certain locality is Nertschinsk in Siberia.

320. VANADINITE, *v. Kobell;* Vanadiate of Lead, *Phillips:* Vanadinbleierz, *Mohs.*

Hexagonal, hitherto only ∞P . 0P, prismatic, small. Cleavage, not distinctly perceptible. H. = 3; G. = 6·8 — 7·2. Opaque; lustre resinous, but dull; colour yellow and brown; streak white. B.B. decrepitates violently, and on charcoal fuses to a globule, which emits sparks and is reduced to lead, colouring the support yellow. With salt of phosphorus it forms in the oxidating flame a glass reddish-yellow when warm, yellowish-green when cold; in the reducing flame, a beautiful chrome-green glass (variety from Beresow, *G. Rose*). That from Wanlockhead fuses in the forceps, and retains its yellow colour when cold. On charcoal yields odour of arsenic (*Johnston*). Easily soluble in nitric acid. Chem. com. perhaps 3 $Pb^3 \dot{V} + Pb\,Cl$. Analyses.

	Lead oxide.	Lead.	Vanadic acid.	Chlorine.	Zinc oxide.	Copper prot.	Watr.	Iron perox. silica.	Total.	
1	66·33	7·06	23·43	2·45*a*	...	...	...	0·16	99·44	R. D. Thomson.
2	63·73	6·62	15·86	2·27	6·35	2·96	3·80	...	101·58	Damour.

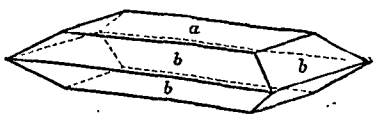
(*a*· Muriatic acid.

In vanadinite from Zimapan in Mexico, Berzelius found 74·00 basal vanadiate of lead, 25·33 basal chloride of lead, 0·67 hydrous peroxide of iron, and a trace of arseniate of lead. No. 1 was said to have been found in Wicklow in Ireland, but Thomson thinks was more probably from Wanlockhead, where it occurs in light brownish-yellow hexagonal prisms. Other crystals of an orange colour seem to have rather a different composition. At Beresow near Katharinenburg in Siberia, it is found in the auriferous veins along with the pyromorphite. The locality of No. 2 is unknown. It also occurs at Matlock in Derbyshire.

321. WULFENITE, *Haidinger;* Molybdate of Lead, *Phillips;* Gelbbleierz, *Werner;* Plomb molybdaté, *Hauy;* Pyramidal Lead-Baryte, *Mohs.*

Tetragonal, P 131° 35′ (131° 30′—132°, *Breit.*); the most common forms are 0P (*a*), $\frac{1}{4}$P (*b*), $\frac{1}{3}$P, P, ∞P, $\frac{1}{2}$P∞, and P∞; the crystals partly tabular (fig. 213), partly short prismatic or pyramidal, usually collected in druses. Cleavage, pyramidal along P rather perfect, basal imperfect. Fracture conchoidal to uneven; rather brittle; H = 3; G. = 6·3 — 6·9. Semitransparent to translucent on the edges; lustre resinous or adamantine; colourless, but generally coloured yellowish-grey, wax, honey, or orange-yellow.

Fig. 213.



B.B. decrepitates violently; on charcoal fuses and sinks into the support, leaving lead behind. Easily reduced with soda; readily soluble in salt of phosphorus, forming a glass of a green, or, with more assay, of a black colour. The powder is decomposed by warm nitric acid, throwing down yellowish-white nitrate of molybdena. In concentrated hydrochloric acid forms a yellow solution, from which chloride of lead separates. Also soluble in sulphuric acid and in solution of potash. Chem. com. $\dot{P}b\,\dot{M}o$, with 60·9 protoxide of lead and 39·1 molybdic acid. Analyses.

	Lead prot.	Molybd. acid.	Iron perox.	Lime.	Silica.	Total.	
1	59·23	34·25	...	...	...	93·48	Klaproth, Bleistadt (cor. by Ram.)
2	58·40	37·00	3·08	...	0·28	98·76	Hatchett, Do.
3	59·0	40·5	...	...	...	99·5	Göbell, Do.
4	61·90	40·29	...	...	...	102·19	Melling, Do.
5	43·0	42·2	8·5	6·3	...	100·0	Domeyko, Chili.
6	73·8	10·0	1·7	..	3·7*a*	98·1	Boussingault, Paramp-Rico.

(*a*) + 2·9 carbonic acid, 1·3 muriatic acid, 1·3 phosphoric acid, 1·2 chromic acid, and 2·2 alumina.

In some varieties Rammelsberg observed vanadium, perhaps from a mixture of vanadiate of lead. The red crystals from Rezbanya contain, according to G. Rose, only a small amount of chrome, and in other respects agree with the Bleiberg variety.

In No. 5 the iron peroxide is perhaps only a mixture, though the specimen was crystallized, and the lime may replace part of the lead protoxide. The variations in specific gravity and angular dimensions noticed by Breithaupt are probably also caused by lime. No. 6, which occurs in small yellowish-green concretions, G. = 6·0, in a decayed syenite near Pamplona in South America, has been considered a basal molybdate of lead, $\dot{P}b^3\,\dot{M}o$; but seems a mere mixture.

It occurs in beds and veins in limestone at Bleiberg and other places in Carinthia, in Austria, the Tyrol, and Hungary. Also in Baden, Saxony, Dauphiné, and in small amount in Massachusets and Philadelphia, and at Zimapan, Mexico.

322. SCHEELITINE, *Beudant;* Tungstate of lead, *Phillips;* Scheelbleierz, *Naumann;* Stolzit, *Haidinger;* Dystomous Lead-Baryt, *Mohs.*

Tetragonal and pyramidal-hemihedric; P 131° 30′. It generally forms very acute pyramidal, almost spindle-shaped, crystals of the combination 2P . P . ∞P; rarely they are short prismatic. Most frequently they are small, indistinct, and combined in bud-like or spherical groups. Cleavage along P imperfect. H. = 3; G. = 7·9 — 8·1. Semitransparent or translucent; lustre resinous; coloured grey, brown, yellow, or green. B.B. fuses, stains the charcoal with oxide of lead, and on cooling forms a dark crystalline grain; with salt of phosphorus in the oxidating flame gives a colourless, in the reducing flame a blue glass; with soda yields beads of lead. Soluble in nitric acid, with a precipitate of yellow tungstic acid. Chem. com. $\dot{P}b\,\ddot{W} = 51{\cdot}54$ tungstic acid, and 48·46 protoxide of lead. Lampadius found 51·75 tungstic acid, and 48·25 lead protoxide. It is only found in druses with quartz and mica in the tin mines at Zinnwald in Bohemia; and perhaps also at Bleiberg in Carinthia. The similarity of its crystallization to that of scheelite confirms the isomorphism of lime and protoxide of lead when in union with the same acid.

323. PLOMBGOMME, *Laumont, Allan;* Hydrous Aluminate of Lead, *Phillips;* Plomb hydro-alumineux, *Hauy;* Bleigummi, *Mohs, &c.*

Botryoidal, reniform, or stalactitic masses, with an apparent prismatic cleavage (?). Fracture conchoidal and splintery. H. = 4 — 4·5; G. = 6·3 — 6·4. Translucent; lustre vitreous, inclining to resinous; colour yellowish or greenish-white, to reddish-brown, often in stripes. In the closed tube yields water and decrepitates violently. B.B. on charcoal becomes opaque and white, intumesces, and partially fuses; with soda it is reduced to lead, and with solution of cobalt becomes blue. Soluble in nitric acid. Chem. com. $\dot{P}b^3\,\ddot{\dot{P}} + 6\,\ddot{A}l\,\dot{H}^3$, by Damour's analysis, neglecting the chloride of lead, and adding the lime to the protoxide of lead, the iron peroxide to the alumina. Analyses, next page.

In the older analyses the phosphoric acid was overlooked. It occurs with galena and other lead ores at Poullaouen in Brittany, and at Nussiére near Beaujeu. In general aspect it much resembles

	Lead prot.	Phosph. of Lead.	Phosphoric acid.	Alumina.	Watr.	Mixtures.	Total.	
1	40·14	...	...	37·00	18·80	2·60	98·54	Berzelius, Huelgöet, G. 6·4.
2	37·51	7·92	...	34·23	16·13	2·11*a*	97·77	Dufrénoy, Nussiére, G. 4·88.
3	35·10	...	8·06	31·32	18·70	2·27*b*	99·75	Damour, Huelgöet.
4	10·0	...	25·5*c*	23·0	38·0*d*	3·0*e*	99·5	Berthier, Carmeaux.

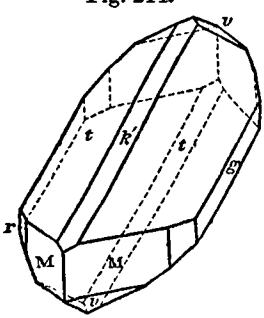
(*a*) Silica; (*b*) chloride of lead + 0·80 lime, 0·20 iron peroxide, and 0·30 sulphuric acid; (*c*) with trace of arsenic acid; (*d*) with organic matter; (*e*) copper protoxide.

gum-arabic. No. 4 is a recent sinter found in the mines near Carmeaux with arseniate of copper; and, as Berzelius states, is essentially a hydrous phosphate of alumina, $\ddot{A}i^4\,\ddot{\dot{P}}^8$, mixed with phosphate of lead, $\dot{P}b^3\,\ddot{\dot{P}}$.

324. CROCOISITE, *v. Kobell;* Krokoit, *Breithaupt;* Chromate of lead, *Phillips;* Red-lead spar, *Jameson;* Rothbleierz, *Werner;* Plomb chromaté, *Hauy;* Hemiprismatic Lead-baryte, *Mohs.*

Monoclinohedric; C = 78°, ∞P 93° 44′, —P 119°; 4P∞ 15° 7′; usual combination ∞P (*M*) . (∞P∞) (*g*) . —P (*t*) . 4P∞, with other forms. The crystals are prismatic along ∞P, sometimes also along —P (fig. 214), vertically striated and united in druses, or attached by one of the sides of the prism. Cleavage, prismatic along ∞P rather distinct; orthodiagonal and clinodiagonal imperfect. Sectile. H. = 2·5 — 3; G. = 5·9 — 6·1. Translucent; lustre adamantine; colour hyacinth or aurora-red. Streak orange-yellow. B.B. decrepitates, blackens and fuses on charcoal, the lower part being reduced to lead; with borax or salt of phosphorus forms in the oxidating flame a green, in the reducing flame a grey glass. Easily reduced with soda. Soluble in warm hydrochloric acid with precipitate of chloride of lead. With nitric acid forms with difficulty a yellowish-red solution. In solution of potash becomes first brown, then forms a yellow solution. Chem. com. $\dot{P}b\,\ddot{C}r$ = 31·7 chromic acid and 68·3 lead protoxide. Analyses.

Fig. 214.



	Chrom. ac.	Lead protox.			
1.	31·73	67·91	=	99·64	Pfaff.
2.	31·50	68·50	=	100	Berzelius.

Vauquelin, who discovered chrome in the Siberian variety of this mineral in 1797, and Thénard, give 36 per cent. chromic acid, but

their methods were imperfect. It occurs in quartz veins in a talcose mica slate, or in limestone at Beresow in Siberia with galena, vauquelinite, and native gold, and also near Mursinsk, and Nischne-Tagilsk in the Ural. Very fine specimens are procured at Congonhas do Campo in Brazil from a quartz vein in mica slate. Rezbanya in Hungary, Moldawa in the Bannat, and Tarnowitz in Silesia, are other localities, Both the mineral and the artificial salt are used as a pigment; but the colour is not permanent.

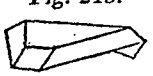
325. MELANOCHROITE, *Hermann, Phillips, Mohs;* Phœnikochroite, *Glocker.*

Rhombic, dimensions unknown. It occurs in small, almost rectangular, tabular crystals, often in fan-shaped or in cellular intersecting groups. Cleavage, in various directions, but imperfect. H. = 3 — 3·5; G. = 5·75. Translucent on the edges; lustre resinous or adamantine; colour cochenile to hyacinth-red; streak brick-red. In the closed tube it becomes temporarily darker, but does not decrepitate. B.B. on charcoal fuses easily to a dark mass that is crystalline when cold. In the reducing flame yields lead. With borax and salt of phosphorus shows reaction for chrome. Soluble in hydrochloric acid, precipitating chloride of lead; when long heated the solution becomes green, and chlorine escapes. Chem. com. according to Hermann, $\dot{P}b^3\ \ddot{C}r^2$, or by his analysis, 23·31 chromic acid and 76·69 protoxide of lead (= 100). It occurs in veins in limestone with other lead ores at Beresow in Siberia.

326. VAUQUELINITE, *Steffens;* Chromate of Lead and Copper, *Phillips;* Plomb chromé, *Hauy;* Hemiprismatic Melanochlor-Malachite, *Mohs.*

Monoclinohedric; C = 67° 15′. The usual form is 0P . —P . —P∞ (with 0P : —P∞ = 149°), in tabular crystals always macled by ∞P∞ (fig. 215), the faces 0P forming an angle of 134° 30′. The crystals are very small, and combined in botryoidal or reniform masses or crusts; also massive. Cleavage unknown; H. = 2·5 — 3; G. = 5·5 — 5·8. Semitranslucent or opaque; lustre resinous; colour blackish or dark olive-green; streak siskin-green. B.B. on charcoal intumesces, frothes up and fuses to a dark-grey metallic globule surrounded by small grains of lead. With borax and salt of phosphorus it forms in the oxidating flame a green, in the reducing flame, especially with tin, a red glass. With soda on platina wire a glass green when warm, yellow when cold, and which colours water yellow from chromate of soda. Partially soluble in nitric acid to a dark-green

Fig. 215.



fluid with a yellow residue. Chem. com. $\dot{C}u^3\ \ddot{C}r^2 + 2\ \dot{P}b^8\ \ddot{C}r^2$, very nearly agreeing with Berzelius' analysis of a specimen from Beresow, 60·87 lead protoxide, 10·80 copper protoxide, 28·33 chromic acid (= 100). It occurs at Beresow in Siberia in quartz veins with crocoisite, and it would appear also with this mineral at Congonhas do Campo in Brazil. It is also found in the Sing-Sing lead mine in New York, and it is said at Pontgibaud in Auvergne.

327. BISMUTHITE, *Breithaupt.*

Occurs disseminated or investing, and in acicular pseudomorphs. Fracture conchoidal or uneven; very brittle; H. = 4 — 4·5; G. = 6·8 — 6·91. Opaque; dull or weak vitreous lustre; colour yellowish-grey, straw-yellow, or siskin-green. B.B. decrepitates, and on charcoal fuses very readily, and is reduced with effervescence to a grain of metal, which soon covers the support with bismuth oxide. In hydrochloric acid it forms a deep yellow solution, containing a little sulphuric acid. According to Plattner, it consists essentially of carbonate, with a little sulphate of bismuth mixed with iron peroxide, copper protoxide, and sulphuric acid as impurities. It occurs at Ullersreuth near Hirschberg in the Voightland, and at Schneeberg and Johann-Georgenstadt in Saxony.

328. KERATE, *Haidinger;* Muriate (Chloride) of Silver, Hornsilver, *Phillips;* Hornerz, *Werner;* Corneous Silver, *Jameson;* Argent chloruré, *Dufrénoy;* Hexahedral Pearl-Kerate, *Mohs.*

Tesseral, chiefly the cube $\infty O \infty$; the crystals are small or very small, attached singly or grouped in rows, steplike forms, or drusy crusts. It likewise occurs massive and disseminated. Cleavage not perceptible. Fracture conchoidal; malleable and yields to the nail; H. = 1 — 1·5; G. = 5·5 — 5·6. Translucent; lustre adamantine resinous; colour grey, occasionally bluish or greenish. B.B. fuses very easily to a grey, brown, or black bead, which in the inner flame is gradually reduced to silver. Fused with copper oxide it colours the flame a beautiful blue. Slightly affected by acids; and slowly soluble in caustic ammonia. Chem. com. Ag Cl, with 75 silver and 25 chlorine. Klaproth's analyses as corrected by Rammelsberg give,

	Silver.	Chlorine.	Iron perox.	Alumina.	Sulph. acid.	Total.	
1	67·75	27·50	6·00	1·75	0·25	103·25	Saxony.
2	68	32	...	...	...	100	Schlangenberg, Siberia.
3	76	24	...	...	..	100	Guantahajo, Peru.

Domeyko says the specific gravity varies from 5·31 to 5·43, and

Dufrénoy states it at 4·702. The kerate seems generally a recent formation, and often occurs on old coins that have been buried in the earth or exposed to sea water. Proust observed it ¼ line thick on the coins recovered from a Spanish vessel shipwrecked on the coast of Portugal.

It occurs especially in the upper part of veins in primary rocks, with other silver ores, as in Saxony at Johann-Georgenstadt, Schneeberg, and Freiberg, but now very rarely; at Joachimsthal in the Erzgebirge, Huelgoet in Brittany, Kongsberg in Norway, in Spain, Schlangenberg in Siberia, and in Cornwall. The finest specimens now come from Mexico and Peru, and have often a green colour. In Chili a compound of the chloride and bromide of silver is said to occur. At Andreasberg in the Harz it is found mixed with clay, the Buttermilcherz of the Germans.

The *Carbonate of Silver* (*Grausilber*, Hausmann; *Selbite*, Haidinger), an ash-grey massive mineral, very soft, effervescing in nitric acid, and B.B. easily reduced, contains according to Selb, 12 carbonic acid, 72·5 silver, and 15·5 carbonate of antimony with oxide of copper. It was from Altwolfach in the Schwarzwald, and seems a mixture, but Hausmann considers it a true species, and identical with the Plata azul, a rich silver ore found in great abundance at Real de Catorce in Mexico.

329. CALOMEL, *Beudant;* Muriate (Chloride) of Mercury, *Phillips;* Quicksilber hornerz, *Werner;* Mercure chloruré, *Dufrénoy;* Pyramidal Pearl Kerate, *Mohs.*

Tetragonal; P 136°. The crystals are prismatic, terminated by pyramids, like fig. 123, p. 368 above, but are very small, often indistinct, and combined in thin drusy crusts. Sectile; H. = 1 — 2; G. = 6·4 — 6·5 (the artificial chloride = 7·0). Translucent or only on the edges; lustre adamantine; colour greyish or yellowish-white. In the closed tube it sublimes as a white mass; and with soda yields mercury. B.B. on charcoal, when pure, wholly volatilizes. With salt of phosphorus and copper oxide colours the flame blue. In nitric acid it is not at all soluble, in hydrochloric acid partially, but wholly and easily in nitro-chloric acid. Becomes black in solution of potash. Chem. com. Hg^2 Cl, with 15 chlorine and 85 mercury. According to Rammelsberg, no quantitative analysis of this mineral exists; but the following is quoted from Klaproth, 76·0 oxide of mercury, 16·4 muriatic acid, and 7·6 sulphuric acid.

Calomel is very rare, its chief locality being Moschellandsberg in Rhenish Bavaria, in a vein of iron ore with cinnabar. The quicksilver mines of Idria in Carniola, Almaden in Spain, and the Giftberg near

Horzowitz in Bohemia, and also it is said the tertiary marls near Montpellier, are other localities.

According to John, another salt of this metal, a Nitrate of Mercury, is found at Johann-Georgenstadt. It much resembles the carbonate of lead or carbonate of lime, but is partially soluble in water. It is undoubtedly a recent production, and its claim to be regarded as a distinct species is very uncertain.

330. IODITE, *Haidinger;* Iodic Silver, *Phillips;* Argent ioduré, *Dufrénoy;* Iodinsilber, *Mohs.*

Occurs in thin flexible foliæ or plates. Malleable. H. = 1 — 1·5; G. = 5·504 (*Domeyko*). Translucent; lustre resinous inclining to adamantine; colour pearl-grey, yellowish-grey, or greenish-yellow. B.B. on charcoal becomes red, fuses easily, colouring the flame purple-red, and leaves a grain of silver. Soluble in very highly concentrated nitric or hydrochloric acid with evolution of iodic fumes. Chem. com. not certainly known. Vauquelin gives 18·5 per cent. iodine, whereas the artificial salt, Ag I, contains 54 iodine and 46 silver; and Domeyko, in the variety from Chili, found 35·75 iodine and 64·25 silver.

It occurs with native silver in serpentine at Albarradon near Mazapil in Zacatecas, Mexico; in porphyry in the mountains south of Arqueros in Chili; and has recently been found at Hiendelencina in Guadalajara in Spain.

331. COCCINITE, *Haidinger;* Iodic mercury, *Phillips;* Mercure ioduré, *Dufrénoy;* Iodquecksilber, *Hausmann.*

This mineral, of a scarlet-red colour, easily fusible, and subliming, is said by Del Rio to occur at Casas Viejas in Mexico, and to be used as a pigment. Chem. com. probably Hg I, with 44·3 mercury and 55·7 iodine, or that of the artificial salt; which, according to Mitscherlich, is dimorphous, crystallizing in tetragonal pyramids, so much truncated by 0P as to appear tabular and of a beautiful red colour; but when fused it becomes yellow, and forms by sublimation right rhombic prisms.

332. BROMITE, *Haidinger;* Bromic silver, *Dana;* Bromsilber, *Hausmann;* Bromure d'Argent, *Berthier*, *Dufrénoy.*

Tesseral, ∞O∞ and O. The crystals are very small; it also occurs in crystalline grains. H. = 1 — 2; G. = 5·8 — 6. Very splendent, colour olive-green or yellow, with grey tarnish. Streak siskin-green. B.B. very easily fusible. Is scarcely affected by acids, but

soluble in concentrated ammonia when warm. Chem. com. Ag Br, or, according to Berthier's analysis, 57·5 silver and 42·5 bromine. It is often mixed with carbonate of lead, peroxide of iron, and clay. Bromite occurs in considerable abundance in the San Onofre and other mines in the district of Plateros in Mexico, where it is named *plata verde*, and used as an ore of silver. It accompanies kerate in the silver mines of Copiapo in Chili, and, according to Berthier, also in those of Huelgöet in Brittany.

333. Roméite, Romeine, *Damour*, *Dufrénoy*, *Dana*.

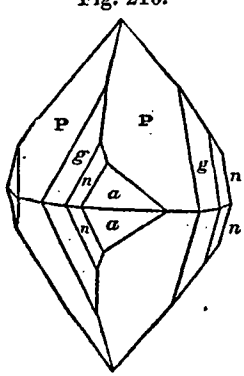
Tetragonal, P 110° 30′, and consequently very like an octahedron. The crystals are small and in groups, or inclosed in the massive mineral; scratches glass; colour honey-yellow or hyacinth-red. B.B. fuses to a blackish-slag. With borax forms in the reducing flame a colourless, in the oxidating flame a violet, glass. Not soluble in acids. Chem. com. perhaps $\dot{C}a^4\ddot{S}b^3$, part of the lime being replaced by protoxides of manganese and iron. Damour's analysis gave 79·31 antimonious acid, 16·67 lime, 2·60 manganese protoxide, 1·20 iron protoxide, and 0·64 silica (= 100·42).

It has been found in the manganese mines at St Marcel in Piedmont, and is named in honour of the celebrated crystallographer Romé de L'Isle.

334. Scheelite, *v. Leonhard*, *Beudant*; Tungsten, *Scheele*, *Jameson*; Tungstate of Lime, *Phillips*; Schéelin calcaire, *Hauy*; Schwerstein, *Werner*; Pyramidal Scheel-Baryte, *Mohs*.

Tetragonal and pyramidal-hemihedric, P 112° 1′, often alone. The usual combinations are P (*P*) . 2P∞ (*g*); 2P∞ . P . 0P; 0P . ½P. The character of the crystals is mostly pyramidal (fig. 216), rarely tabular, like fig. 213 above; and they are attached singly or in groups and druses. Cleavage, pyramidal along 2P∞ 129° 2′ rather perfect, along P and 0P less perfect. Fracture conchoidal and uneven; H. = 4 — 4·5; G. = 5·9 — 6·2. Translucent; lustre vitreous, inclining to resinous on the fracture, to adamantine on the crystal faces and cleavage; colourless, but usually coloured grey, yellow, or brown, rarely orange-yellow or green; streak white. B.B. fuses difficultly to a translucent glass. With borax to a clear colourless bead, which, if not fully saturated, remains clear when cold, but if again slowly heated, be-

Fig. 216.



comes opaque and enamel-like; if fully saturated it becomes milk-white, and crystalline immediately on cooling. With salt of phosphorus forms a glass, which, in the oxidating flame, is clear and colourless, in the reducing flame green when warm, blue when cold. Decomposed in hydrochloric or nitric acid, leaving tungstic acid; also in solution of potash, with precipitate of lime. Chem. com. when pure, Ca W, with 80·6 tungstic acid and 19·4 lime, but it generally contains silica and iron peroxide, or rarely copper protoxide when the mineral is green. Analyses.

	Lime.	Tungstic acid.	Silica.	Iron perox.	Mang. perox.	Total.	
1	17·60	77·75	3·00	...	...	98·35	Klaproth, Schlackenwald.
2	18·70	75·25	1·50	1·25	0.75	97·45	Do. Pengilly, Cornwall.
3	19·40	80·42	...	...	...	99·92	Berzelius, Westmanland.
4	19·06	78·00	2·00	...	...	99·06	Brandes and Bucholz, Schlackenwald.
5	16·60	76·50	2·94	1·50	...*a*	98·54	Do. and Do. Zinnwald.
6	19·36	76·05	2·54	1·03	0·31	99·29	Bowen, Huntington, Connecticut.
7	18·05	75·75	0·75	...	...*b*	97·85	Domeyko, Coquimbo, Chili.
8	21·56	78·64	...	...	...	100·20	Rammelsberg, Neudorf (G. = 6·03).
9	18·88	78·41	...	...	...*c*	97·94	Choubine, Katherinenburg (G. = 6·071).

(*a*) + 1·10 alumina and lime; (*b*) + 3·30 copper protoxide; (*c*) + 0·65 magnesia.

In the tungsten (hystatic), G. = 5·97 — 5·99, from Zinnwald, Breithaupt finds hydrochloric and fluoric acids; in that from Schlackenwald (macrotype, G. = 6·2), from 2 — 3 per cent. of fluoric acid.

This mineral occurs with wolfram, especially in veins of tin ore, sometimes in beds with gold or magnetic iron, also with galena and quartz. The finest crystals have been found in quartz at Caldbeckfell near Keswick: at Zinnwald and Schlackenwald in Bohemia, and the above localities. It is also found in the gold mines of Schellgaden in Salzburg, and of Pösing in Hungary; in the copper mines of Llamuco in Chili (No. 7), of a green colour; and at Katherinenburg in Siberia. At the Monroe mines in Connecticut it has been used in preparing tungstic acid, which forms a very fine yellow pigment, superior to chrome-yellow; but the mineral is too rare to be generally used.

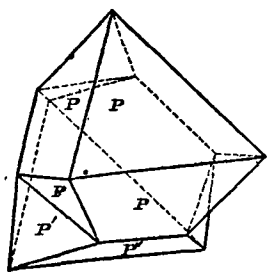
IV. ORDER.—OXIDIZED ORES.

I. Family.—Oxidized Iron Ores.

335. Magnetite, *Haidinger;* Magnetic Iron, *Allan;* Oxidulated Iron, *Phillips;* Magneteisenerz, *Naumann;* Magneteisen, *v. Leonhard;* Fer Oxydulé, *Hauy;* Octahedral Iron ore, *Mohs.*

Tesseral; O and ∞O are the most frequent and predominant forms; also ∞O∞, 2O2, 2O, and others. Macles are common, united by a plane of O (fig. 217). The crystals occur imbedded or in druses. Generally it is found massive in granular or almost compact aggregates; often also in loose grains, forming magnetic sand. Cleavage, octahedral sometimes perfect, at other times in mere traces. Fracture conchoidal or uneven; brittle; H. = 5·5 — 6·5; G. = 4·9 — 5·2. Opaque; lustre metallic, sometimes imperfect; colour iron-black, occasionally inclining to brown or grey; highly magnetic. B. B. becomes brown and non-magnetic, and fuses with extreme difficulty; powder soluble in hydrochloric acid. Chem. com. $\dot{F}e\,\ddot{F}e$, with 31·03 of the protoxide and 68·77 of the peroxide of iron, or 72·40 iron and 27·60 oxygen. Analyses.

Fig. 217.



	Iron perox.	Iron prot.	Mang. prot.	Vein-stone.	Total.	
1	69	31	...	...	100	Berzelius, Sweden.
2	74·96	25·04	...	...	100	v. Kobell, crystallized, Schwarzenstein.
3	73·84	21·40	2·00	2·68*a*	100	Do. foliated, Arendal.
4	69·95	29·53	0·25*b*	0·15	99·88	Karsten, crystallized, Dannemora.
5	66·23	27·65	...	5·95	99·83	Do. massive, Thorsaker, Sweden.
6	69·40	28·25	1·85*c*	...	99·50	Do. granular, Gellivara, Lapland.
7	68·03	29·25	...	2·45	99·73	Do. massive, Arendal.
8	67·95	29·92	...	1·86	99·73	Do. cryst., Berggeishübel, Saxony.
9	67·56	28·66	3·31*b*	...	99·53	Do. cryst., Tyrol.
10	68·40	30·88	...	...	99·28	Fuchs, crystallized.

(*a*) Silica; (*b*) titanic iron; (*c*) specular iron.

From his analyses of iron ore from Schwarzenstein in the Zillerthal (No. 2 above, mean of three), v. Kobell deduces the formula $\dot{F}e^{3}\,\ddot{F}e^{4}$, which gives 25·19 of the protoxide and 74·81 of the peroxide. Hence there are either more than one variety of this ore, or, as

is more probable, it is occasionally mixed with specular iron ore. Breithaupt regards the varieties with the formula $\dot{F}e^3\ \ddot{F}e^4$, as distinct from the others, and says that they possess greater hardness and higher specific gravity.

Some highly-magnetic varieties, especially from Siberia and the Harz, form natural magnets, possessing distinct polarity. Others only become polar after contact with magnets of sufficient power; and some require to be touched before they will even attract iron filings.

Magnetic iron occurs especially in igneous or metamorphic rocks, either in distinct crystals, or, as in many basalts, disseminated through the mass, when it frequently imparts magnetic properties to the rocks, especially to granite, serpentine, or basalt. It also forms beds in gneiss, in chlorite, mica, hornblende, and clay slates, in marble, greenstone, and other rocks, but seldom appears in veins. The largest known masses occur in the northern parts of the globe, in Scandinavia, Lapland, Siberia, and North America. In Norway, Arendal is the most important locality; in Sweden, Dannemora, Utoe, Norberg, Taberg; in Lapland, Kurunavara and Gellivara; in the Ural, Wissokaja Gora near Nischne-Tagilsk; Blagodat near Kuschwinsk, and the Kaschkanar near Nischne-Turjinsk. Less extensive masses occur in the Harz, in Saxony, Bohemia, Silesia, and Styria; and in Southern Europe, in Elba and Spain. It is also found in Mexico and Brazil. Beds of magnetic iron ore are known in several parts of Scotland; but, from the distance from fuel and the abundance of other ores, have attracted little notice.

Magnetite is the most important ore of iron in Norway, Sweden, and Russia. The quality of the iron is much affected by the associated minerals, of which pyrites and apatite are especially prejudicial. The Dannemora mines, wrought in an open quarry 150 feet broad and 500 deep, furnish the fine Oeregrund iron, largely imported into England for the manufacture of steel. The fine quality is ascribed to the ores being mixed with calc-spar, which, with garnet, thallite, augite, and hornblende, is considered highly advantageous for their reduction, and the granular ores often require no other flux. The compact varieties, especially when mixed with quartz, are on the contrary very difficultly fusible.

This mineral often changes slowly into the oxyhydrate of iron. The fine octahedral crystals of specular iron, found in Brazil and the Ural, show that it may also, in certain circumstances, be converted into the peroxide. It is, on the other hand, sometimes formed during smelting processes, especially where atmospheric air or aqueous vapour have come in contact with the hot iron. The latter seems particularly favourable to the formation of crystals.

336. CHROMITE, *Haidinger;* Chromate of Iron, *Phillips, Allan;* Chrom-Eisenstein, *Werner;* Fer chromaté, *Hauy;* Octahedral Chrome Ore, *Mohs.*

Tesseral; only in octahedrons. It generally occurs massive and granular. Cleavage, octahedral imperfect; fracture imperfect conchoidal or uneven. H. = 5·5; G. = 4·4 — 4·5. Opaque; lustre semi-metallic or resinous; colour iron or brownish-black; streak yellowish to reddish-brown. Sometimes magnetic; weak electric conductor. B.B. infusible alone, and remains unchanged, except that the non-magnetic varieties when ignited in the reducing flame become magnetic. In borax it is slowly soluble, forming a bead emerald-green when cold. Fused with nitre it forms a yellow solution in water, which shows reaction for chromic acid. Scarcely affected by acids. Chem. com. $(\dot{F}e, \dot{M}g)$ $(\ddot{C}r, \ddot{A}l)$. Analyses.

	Iron prot.	Chrome perox.	Alumina.	Magnesia.	Silica.	Total.	
1	37·0	36·0	21·5	...	5·0	99·5	Berthier, St Domingo.
2	25·66	54·08	9·02	5·36	4·83	98·95	v. Kobell, Röraas, Norway.
3	36·00	39·61	13·00	...	10·60	99·11	Seybert, Baltimore.
4	35·14	51·56	9·72	...*a*	2·90	99·32	Do. Chester, Pennsyl.
5	20·13	60·04	11·85	7·45	...	99·47	Abich, Baltimore, cryst.
6	18·97	44·91	13·85	9·96	0·83	98·25	Do. Do. massive.

(*a*) Trace of protoxide of manganese.

Chromite occurs generally in serpentine, or in crystalline limestone near this rock, either in veins, nests, or disseminated. It is found in Saxony, Silesia, Bohemia, and Styria (Kraubat); at Gassin in the Var department in France, where it was first discovered; in Norway at Röraas; in the Ural in large masses near Katherinenburg, and in the gold washings in grains; in many parts of the United States, as the Barehills near Baltimore, Chester in Massachusets, and Hoboken in New Jersey. In Scotland it has been found in great abundance in Unst and Fetlar in the Zetlands, and also at Portsoy in Banff and other places. It is used in the preparation of various pigments, the chromate of potash being first produced, and then converted into chrome peroxide (chrome-green) or chromate of lead (chrome-yellow).

337. FRANKLINITE, *Berthier, Phillips;* Dodecahedral Iron ore, *Mohs.*

Tesseral; O and O . ∞O being the most usual forms. The crystals, often rounded on the edges and angles, occur imbedded or united in druses; it also forms granular masses. Cleavage, octahedral, but in general very imperfect. Fracture conchoidal or uneven; brittle.

H. = 6 — 6·5; G. = 5·0 — 5·3. Opaque; imperfect metallic lustre; colour iron-black; streak dark reddish-brown. B.B. infusible, but shines brightly and gives out sparks when strongly heated in the forceps. On charcoal, especially with soda in the reducing flame, forms a deposition of zinc; with borax in the outer flame fuses to a red glass, which becomes brown when cold. Soluble in hydrochloric acid. Chem. com. probably (Ḟe, Żn, Ṁn) ($\dddot{F}e$, $\dddot{M}n$). Analyses.

	Iron perox.	Mang. perox.	Zinc oxide.	Alumina.	Silica.	Water.	Total.	
1	66	16	17	...	...	...	99	Berthier.
2	66·10	14·96	17·43	...	0·20	0·56	99·25	Thomson.
3	68·82	13·17	16·81	0·73	0·40	...	98·99	Abich.
4	41·93	7·60*a*	16·80	30·49	2·97	0·40	100·19	Thomson.

(*a*) Protoxide.

Occurs with red oxide of zinc, calc-spar, and garnet at Franklin in New Jersey, and at Sterling in a vein with troostite; and, according to Allan, also in the Altenberg mines near Aix-la-Chapelle.

The *Dysluite* of Thomson, No. 4, also from Sterling, *N. J.*, opaque, dark or yellowish-brown, with vitreous lustre, and G. = 4·5, seems this species with a large part of the peroxides of iron and manganese replaced by alumina. According to Rammelsberg, the iron is partly the protoxide = 12·55, partly the peroxide = 27·96. Breithaupt's *Isophane*, or isophane iron ore, crystallizing in octahedrons, iron-black, with brown streak, and G. = 5·01, seems also franklinite.

338. HÆMATITE, *Hausmann;* Specular iron, *Phillips;* Blutstein, Eisenglanz, Rotheisenstein, *Werner;* Fer oligiste, *Hauy;* Oligiste, *Beudant;* Rhombohedral iron ore, *Mohs.*

Rhombohedral; R 86°, usual forms, R, 0R, ¼R 143°, —½R, —2R, ⅔P2 and ∞P2, the general aspect of the crystals being rhombohedric when R, prismatic when ⅔P2, or tabular when 0R predominates. The more common combinations are R . 0R, 0R . R (fig. 218), R . —½R . ∞P2, R . ⅔P2 . 0R, ⅔P2 . R . ¼R, (or *n*, *P*, *s*) (fig. 219).

Fig. 218.

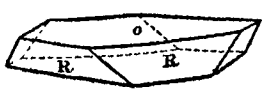
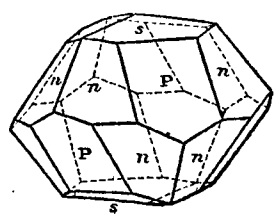


Fig. 219.



The crystals are imbedded, or oftener attached and united in groups and druses. Macles occur with parallel axes, and mostly intersecting. It also appears in granular, foliated, and scaly masses, or botryoidal, reniform, columnar, or fibrous. Cleavage, rhombohedral along R, and basal, but seldom distinct, sometimes scarcely perceptible, and the basal often rather a foliated structure. Fracture conchoidal or uneven; brittle, H. = 5·5 — 6·5; G. = 5·1 — 5·3. Opaque, or in very thin laminæ translucent and deep blood-red. Lustre metallic; colour iron-black to steel-grey, but often tarnished; also various shades of red; streak cherry-red or reddish-brown. Usually weak magnetic. B.B. in the reducing flame it becomes black and magnetic, and acts like iron peroxide. Slowly soluble in acids. Chem. com. $\dot{F}e$, with 70·03 iron and 29·97 oxygen, but sometimes contains oxide of titanium, chrome, or silica, which then affect its action B.B. In a variety from St Gotthardt, v. Kobell found 85·33 iron peroxide, 5·01 iron protoxide, and 9·66 titanic acid; and in another from Switzerland, 94·82 iron peroxide, 3·57 titanic acid, and 1·61 manganese peroxide. According to H. Rose, the titanium in this mineral occurs as the acid.

Some authors divide this species into two, the proper specular iron ore, with crystalline structure and high metallic lustre; and the red hæmatite or more compact varieties. There is a gradual transition from the one to the other, and the difference is chiefly in the size of the individual parts. Some varieties have received particular names, as the *micaceous specular iron* (*Eisenglimmer*), with thin lamellar structure, which, when still finer or scaly, passes into the *red iron froth* (*Eisenrahm*). The red hæmatite or red iron, generally with inferior lustre, lower specific gravity (= 4·5 — 4·9) and hardness (= 3 — 5), and deeper blood-red or brownish-red colours, comprises the *Fibrous red iron*, (*Rother Glaskopf*, Werner; *Fer oligiste concretioné*, Hauy), reniform, botryoidal, and stalactitic masses, often with an irregular concentric structure; the *compact* and *ochrey* iron ores, similar masses with a more earthy or minute texture; the *reddle* or red chalk, still more earthy, and used as a drawing material; and the *jaspery*, *columnar*, and *lenticular clay iron*, mere impure varieties with no essential distinction.

The magnetic property does not arise, as is often asserted, from a mixture of the protoxide of iron, for the pure peroxide can acquire magnetism and polarity often in a high degree. The experiments of Hausmann, Henrici, H. Rose, and others, show that it depends chiefly on the state of aggregation, the more crystalline and compact varieties being also the more highly magnetic, and more easily receiving

magnetism by contact. Von Kobell has named these *Eisenrose*, or Basanomelan, but they are not distinct.

Hæmatite is one of the most abundant ores of iron. The specular variety occurs chiefly in the older crystalline rocks, in large beds or veins. The mines of Elba, celebrated from antiquity, still furnish the finest crystals, which occur in druses of the massive variety along with pyrites and quartz. St Gotthardt, Framont in the Vosges mountains, Arendal, Langbanshytta in Sweden, Tilkerode in the Harz, Altenberg in Saxony, Capas in Brazil, Katherinenburg and Nischne-Tagilsk in the Ural, also produce fine crystals. Beautiful specimens of the micaceous variety occur at Zorge and other parts of the Harz, at Tincroft in Cornwall, Tavistock in Devonshire, in Wales, Cumberland, and Perthshire. At St Just in Cornwall, and various localities in Germany, it forms a constituent of granite; and the Itabirite of Brazil is a schistote or granular mixture of this mineral with quartz. It also occurs in volcanic rocks, as in Auvergne, on Vesuvius, Ætna, and the Lipari islands, especially Stromboli, where some fine crystals, three inches broad and four long, have been procured. The red hæmatite is very common in the Harz and other places in Germany, and in fine reniform masses near Ulverstone in Lancashire, and in many other parts of Britain.

The haematite is not very liable to decomposition, and the beautiful tarnish colours, like those on polished steel, arise less from a change of the surface than from a thin covering of some foreign matter, such as the hydrated peroxide of iron. The haematite is occasionally produced from a gradual change of pyrites or of siderite, and sometimes appears in pseudomorphs, with the form of these minerals. At Lostwithiel in Cornwall, fine red crystals of pure iron peroxide, with the exact dimensions of the götheite, occur, which Haidinger considers pseudomorphs of the latter. The octahedral crystals from Brazil, named *Martite* by Breithaupt, are a similar formation after the magnetite. The ignition of coal mines has also produced it from the siderite; and that found in volcanos, as Vesuvius and Stromboli, according to Covelli, is a result of the action of aqueous vapours on chloride of iron. Mitscherlich has seen crystals of hæmatite formed in a similar manner in a potter's oven at Oranienburg.

339. IRITE, *Hermann.*

Occurs in fine iron black scales with strong metallic lustre, which mark paper, either filling cavities in the larger pieces of native platina, or in more abundance mixed with the ferruginous platina sand of the Ural. G. = 6·506. Strongly magnetic. B.B. fused with nitre gives out the odour of osmium. Insoluble in acids. Chem. com. perhaps (Ir, Os, Fe) ($\dot{I}r$, $\dot{O}s$, $\dot{C}r$); or, by an analysis of Hermann, 62·86 per-

oxide of iridium, 10·30 osmium protoxide, 12·50 iron protoxide, 13·7 chrome oxide with traces of manganese (= 99·36). It has recently been stated to contain also the new metal ruthenium.

340. LIMONITE, *Beudant;* Brown Hematite, *Phillips;* Brown Iron ore, *Allan;* Brauneisenstein, *Werner;* Fer oxidé, *Hauy,* in part; Prismatic Habroneme ore, *Mohs.*

Crystallization unknown (but perhaps rhombic). It has only been found fine fibrous, in spherical, reniform, and stalactitic masses, often with a radiating texture, and dividing into curved concentric laminæ with smooth or rough surfaces. Compact and earthy varieties also occur in various states of aggregation. Fracture fine fibrous, compact, or earthy. H. = 5 — 5·5; G. = 3·4 — 3·95. Opaque; lustre weak silky, glimmering, or dull; colour brown, especially yellowish, clove, hair, and blackish-brown, also yellow and green; streak yellowish-brown. In the closed tube yields water, and the powder becomes red. B.B. in the outer flame also becomes red on ignition; in the inner flame thin splinters fuse to a black magnetic glass; with fluxes acts like iron peroxide. Chem. com. essentially $2\,\ddot{F}e + 3\,\dot{H}$, with 85·6 peroxide of iron (= 60 iron), and 14·4 water. Analyses.

	Iron perox.	Watr.	Mang. perox.	Silica.	Alumina.	Phos. acid.	Total.	
1	82·0	14·0	2·0	1·0	...	...	99·0	D'Aubuisson, Vicdessos.
2	62·93	10·41	trace	22·20	1·84	1·33	98·71	Kersten, Willsdruff.
3	80·76	12·71	...	4·58	2·63	...*a*	101·60	Rammelsberg, Carlshütte, Brunswick.
4	83·38	15·01	...	1·61	...	...	100	v. Kobell, Kamensk, Perm.
5	82·24	13·26	...	4·50	...	...	100	Do. Minden, Prussia.
6	82·07	13·46	traceb	0·67	...	3·00	100	Do. Siegen.
7	86·77	13·23	...	...	...	..	100	Amelung, Rübeland, Harz.
8	81·41	17·96	...	0·17	...	...*c*	100	Murray, Hüttenrode.

(*a*) + 0·92 lime; (*b*) with copper and lime; (*c*) + 0·46 carbon.

Three varieties, the *fibrous* (*brauner Glaskopf*), the *compact*, and the *ochrey*, are distinguished, but they are usually found together, and differ only in their state of aggregation. An uncertainty in regard to the composition of limonite arises from its mixture with other hydrated oxides of iron. In many cases it has been produced from the decomposition of other iron ores; and is often formed by water, containing carbonic acid, extracting from rocks the carbonate of the protoxide of iron, which, on exposure to the atmosphere, loses the carbonic acid, and is deposited as a hydrated peroxide of iron. A similar change often takes place on the carbonate of iron contained in some rocks, which then assume a brown hue; and the hydrated peroxide of manganese, often mixed with the limonite, has had a similar origin, but has a great tendency to separate in dendritic forms. Iron rust is a similar product, the hydrated peroxide being frequently united with

the carbonate of the protoxide. Iron rust absorbs ammonia from the atmosphere, and this alkali has been observed in many limonites. Like other ores of iron, it also contains a small proportion of arsenic, in general too minute for ordinary methods of detection.

Limonite occurs in beds, veins, and nests, in rocks of all ages and formations, often forming the upper portion, whilst the lower consists of unchanged siderite. It is frequently associated with heavy spar, or with calc spar, fluor spar, and quartz, the last often forming stalactitic masses of bluish calcedony. It is a valuable ore of iron, and is wrought as such in many parts of the Harz, near Schmalkald and Camsdorf in Thuringia, at Siegen near Bonn, in Naussau, Styria, and Carinthia. The Pyrenees and Basque Provinces possess it in great abundance, and also Siberia, Brazil, and the United States. In Britain it is found in Cornwall, at Clifton near Bristol, Sandlodge in Zetland, and in many other places. The metal it yields varies much in quality, according to the substances mixed with the ore, but is usually good, uniting hardness with tenacity.

Limonite frequently occurs mixed with other mineral substances, and has then received distinct names, especially from the German miners. Their *Braunerz* or *Mine douce* is limonite with carbonates of lime or magnesia, amounting, in a variety from Styria analyzed by Karsten, to about 5 per cent. each. Some are similar mixtures with clay. The *Kupferbraun* or *Ferruginous red oxide of Copper* of Phillips, sometimes with 22 per cent. suboxide of copper, is reddish or yellowish-brown, with a yellowish-brown streak, and generally occurs near copper mines. The *Kupferpecherz* or *Pechkupfer* of Hausmann is a similar combination of peroxide of iron with copper protoxide (12 per cent.), silica (18), and water, from Siberia. The *Umber* (*Umbra*, Hausmann, *Terre d'ombre*, Hauy) from Cyprus, analyzed by Klaproth, contained 48 per cent. peroxide of iron, 20 peroxide of manganese, 13 silica, 5 alumina, and 14 water; but other umbers vary much in composition, and that from Cologne is merely brown coal finely pulverized. The *Stilpnosiderite* and *Lepidokrokite* of Ullmann seem partly limonite, partly göthite.

Hausmann considers the *Yellow ochre* (*Gelbeisenstein*) as a distinct species, with chem. com $\dot{F}\dot{e} + 2\,\ddot{H}$, or 81·6 peroxide of iron and 18·4 water. In a specimen from Artana in Valencia, Proust found 78·57 peroxide of iron and 21·53 water; and many varieties contain sulphate of iron and other substances, proving it to be a mere product of decomposition. Some varieties are used as a yellow, or when burnt as a reddish-brown pigment. Bunsen has shown that the pure substance is a valuable antidote to the poison of arsenic.

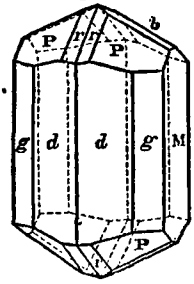
Bog iron ore (*Raseneisenstein*, *Morasterz*, *Wiesenerz*) is also an

hydrated oxide of iron with no definite composition, and often containing thirty to fifty per cent. of impurities. Phosphoric acid is a very frequent constituent, sometimes to 11 per cent.; and also organic acids from plants; Wiegmann in one case finding as much as 14 per cent. of humic acid (?). Bog iron ore occurs chiefly in bogs, meadows, and lakes, especially in the level districts of northern Germany and Sweden. The peroxide is derived from the decomposition of the iron ores, which either form beds or are mixed with the rocks. That found in great abundance in the Smoland lakes has probably been produced from the iron pyrites of the greenstone in the vicinity, as Svanberg observed that it usually contains sulphuric acid, whilst the other elements are such as the decomposed hornblende could furnish. In Britain it is most abundant in the northern and western islands of Scotland. It is easily fused, and serves well for castings, but, from the mixture of phosphoric acid, is unfit for sheet or plate iron, being what is technically termed *cold short.*

341. GÖTHEITE, *Beudant;* Brown iron ore, Hydrous oxide of Iron, *Phillips;* Pyrrhosiderit, *Hausmann;* Nadeleisenerz, *Naumann;* Prismatoidal Habroneme Ore, *Mohs.*

Rhombic; P with polar edges 121° 5′ and 126° 18′, ∞P 94° 53′, ∞$\bar{P}$2 130° 40′, $\breve{P}$∞ 117° 30′. The usual combination is ∞P (*g*) . ∞$\bar{P}$2(*d*). ∞$\breve{P}$∞ (*M*) . P (*P*). $\breve{P}$∞ (*b*) (fig. 220.)

Fig. 220.



The crystals are prismatic, acicular, and capillary, or form thin tables and pointed lamellæ. They are usually small and combined in druses or diverging bundles. It also occurs in columnar, fibrous, or scaly masses, sometimes reniform or hemispherical. Cleavage, brachydiagonal very perfect. Fracture of the aggregates, radiating fibrous; brittle; H. = 5 — 5·5; G. = 3·8 — 4·4. Opaque or in fine lamellæ translucent and hyacinth-red; lustre adamantine or silky; colour yellowish, reddish, or blackish-brown. Streak brownish or reddish-yellow. In the closed tube the powder yields water, and after ignition becomes reddish-brown. B.B. in the oxidating flame also becomes brown; in the reducing flame black and magnetic. It is difficultly fusible, and with borax forms a bottle-green glass. Soluble in hydrochloric acid, often leaving a little silica. Chem. com. $\dot{F}e + \dot{H}$, with 90 peroxide of iron and 10 water. Analyses, next page.

	Iron perox.	Watr.	Mang perox.	Silica.	Total.	
1	86·35	11·38	0·51	0·85a	99·99	v. Kobell, Eiserfield, Götheite.
2	90·53	9·47	...	trace	100	Do. Oberkirchen ? Lepidokrokite.
3	86·34	11·66	...	2·00	100	Do. Saxony, compact brown iron.
4	86·32	10·80	...	2·88	100	Do. Maryland, do. do.
5	86·87	11·13	...	2·00	100	Do. Beresowsk, do. do.
6	86·24	10·68	trace	2·00b	100	Do. Amberg, Stilpnosiderite.
7	85·65	11·50	2·50	0·35	100	Do. Hollerter Zug, Lepidokrokite.
8	88·00	10·75	0·50	0·50	99·75	Brandes, Do. Do.
9	90·02	10·19	...	...	100·21	Hermann, Sterlitamak (pseudomorph).
10	89·95	10·07	0·16	0·28	100·46	Yorke, Lostwithiel, crystals G. = 4·37.
11	83·5	10·3	...	4·3c	100	Breithaupt, Chili, Chileite.

(*a*) + 0·90 protoxide of copper and trace of lime; (*b*) + 1·08 phosphoric acid; (*c*) + 1·9 protoxide of copper.

This mineral was conjoined with limonite, until von Kobell showed that they uniformly differed in the proportion of water. According to Yorke, they may be readily distinguished by the specific gravity, which in this species is 4·37, whereas in limonite it is only 3·71 (or in powder 3·98). Mixtures of the two, however, occur. Many fibrous varieties, when dissolved in acids, leave a residue of gelatinous silica, which Wöhler conjectures may be anthosiderite. Berzelius considered the chileite as a mixture of a silicate and hydrate of iron peroxide.

Götheite occurs in veins often with calc-spar, accompanying various metallic sulphurets, or with quartz in ores of manganese. Sometimes it forms beds with limonite, the two minerals alternating in layers, which in the fibrous varieties are sharply distinguished, but in the compact often seem to pass into each other. It frequently forms pseudomorphs after the carbonate or sulphurets of iron. Götheite is rarer than the limonite, but fine specimens of the foliated variety (*Rubinglimmer*) occur at Eiserfeld near Siegen, and in the Hollerter Zug near Sayn in veins of limonite in transition rocks. Black and highly brilliant crystals are found at Lostwithiel in Cornwall, and with quartz in cavities of sandstone at Clifton near Bristol. The capillary variety is procured of great beauty in veins at Przibram (*Sammetblende*), at Hüttenberg in Carinthia, and near Ulefoss in Norway. It occurs inclosed in rock crystal at Oberstein on the Nahe (the *Stachelschweinstein*, *Hedgehogstone*), and on the Wolf island in lake Onega in Russia (the *Onegite*). The radiated variety is common in the same places with the foliated and in several parts of the Harz. The compact is abundant in Saxony, the Pyrenees, Ural, North America, and many other localities. No. 9 has the form of pyrites, and having been found in the district of Orenburg, inclosed in hail-stones, was on this account thought to be of meteoric origin. The compact variety is an excellent ore.

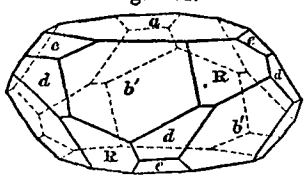
The *Turgit* of Hermann, with 94·15 peroxide of iron and 5·85 water,

or nearly $\dot{\ddot{F}}e^2\ \dot{H}$, is a compact reddish-brown mineral, G. = 3·54 — 3·74, from the Turginsk copper mines in the Ural. It also contained 7·5 per cent. of silica and insoluble matter, with 1·85 protoxide of copper and lead, and is probably a mixture.

342. ILMENITE, *Kupffer;* Titanitic Iron, *Phillips, Allan;* Titaneisenerz, *Naumann;* Kibdelophan, *Hausmann;* Fer oxidulé titané, *Hauy;* Axotomous Iron ore, *Mohs.*

Rhombohedric, and isomorphous with haematite, but sometimes tetartohedral, with only half the faces formed, (though the remaining half are seen in other crystals), and hence very unsymmetrical. R is generally about 86°, but varies from 85° 40′ to 86° 10′. The crystals are composed generally of 0R (*a*) and R, sometimes with $-\frac{1}{2}$R (*e*), —2R (*d*), or with ∞P2, and also $\frac{1}{2}(\frac{2}{3}P2)$ (*b*) (fig. 221); combinations of 0R and 5R also appear. The crystals are tabular or rhombohedral, and occur imbedded or attached, and then often combined in druses or fan-like groups. It likewise forms macles with parallel axes, but very rarely regular. It also occurs in granular or foliated aggregates, or disseminated, or in loose grains. Cleavage, basal more or less perfect, and often rather a lamellar structure; and rhombohedral along R generally less distinct. Fracture conchoidal or uneven. H. = 5 — 6; G. = 4·66 — 5. Opaque; lustre semimetallic; colour iron black, often inclining to brown, rarely to steel-grey. Streak generally black, but sometimes reddish-brown. Slightly or not at all magnetic. B.B. infusible alone, but with salt of phosphorus in the reducing flame forms a red glass. Soluble, but often with much difficulty, in hydrochloric or nitro-chloric acid, leaving titanic acid. Heated in concentrated sulphuric acid gives to it a blue colour. Chem. com. according to H. Rose and Scheerer, a combination of peroxide of iron and the blue oxide of titanium ($\dot{\ddot{T}}i$) in various proportions, the specific gravity increasing with the amount of iron. Thus the variety from

Fig. 221.



		Titanium peroxide.	Iron peroxide.	Specific gravity.
1. Gastein	= 5 $\dot{\ddot{T}}i$ + 4 $\dot{\ddot{F}}e$	53·69	46·31	4·66
2. Iserweise	= 1 ... + 1 ...	48·12	51·88	4·68
3. Lake Ilmen	= 4 ... + 5 ...	42·59	57·41	4·77
4. Egersund	= 2 ... + 3 ...	38·25	61·75	4·74
5. Arendal	= 1 ... + 3 ...	23·62	76·38	4·93
6. Aschaffenburg	= 1 ... + 6 ...	13·39	86·61	4·78
7. Binnenthal	= 1 ... + 10 ...	8·26	91·74	5·127

The proportion, however, seems indefinite, as intermediate varieties occur, and the two oxides are probably isomorphous. The magnetism of some varieties is caused, according to Scheerer, by a mixture of magnetite. The following are a few analyses, the titanic acid being formed by abstracting oxygen from a portion of the iron peroxide, which is thus converted into the protoxide. Analyses.

	Titan. acid.	Iron perox.	Iron prot.	Mang. prot.	Lime.	Magnesia.	Chrm. oxide.	Silica.	Total.	
1	59·00	4·25	36·00	1·65	...	...	...	...	100	v. Kobell, Gastein.
3	46·92	10·74	37·86	2·73	...	1·14	...	...	99·39	Mosander, Ilmen Mount.
4*a*	43·73	42·70	13·57	..	...	...	...	...	100	H. Rose, Egersund.
4*b*	43·24	28·66	27·91	..	...	...	..	...	99·81	v. Kobell, Do.
4*c*	39·14	29·16	27·23	0·21	0·96	2·30	0·12	0·31	99·33	Mosander, Do.
5*a*	23·59	58·51	13·90	...	0·86	1·10	0·44	1·88	100·28	Do. Arendal.
5*c*	20·41	55·23	19·48	...	0·32	0·73	...*a*	0·80	100·61	Do. Do.
6	14·16	76·00	10·04	0·80	...	...	...	...	100	v. Kobell, Aschaffenburg
7	8·58	91·42	...	...	...	...	...	...	100	Rammels., Bimenthal.
8	52·27	1·20	46·53	...	...	...	...	...	100	Marignac, St Christophe.
9	22·21	59·07	18·72	...	...	...	...	...	100	Do. Washington.

(*a*) + 3·64 tin oxide.

The Nos. 1 to 7 in this table correspond with those above, which are calculated from these analyses. No. 4 was massive, the others crystallized. No. 5*a* was non-magnetic; 5*b* magnetic.

Ilmenite occurs in various formations, as in the miascite of the Ilmen mountains; in talc with dolomite at Gastein in Salzburg (*Kibdelophan*, No. 1); in the zircon-syenite at Egersund in Southern Norway; in gneiss with magnetic iron ore at Tvedestrand and Kragerœ near Arendal (*Hystatit* of Breithaupt); in loose grains at Iserwiese in the Riesengebirge (*Iserine*); at Menaccan in Cornwall (*Menaccanite* of Phillips). It is often conjoined with rutile, either regularly or forming a coating on the crystals of the latter. The *Crichtonite* of Bournon, No. 9, with G. = 4·727, found near Bourg d'Oisans in Dauphiné, in druses with rock crystal and anatase, is a mere variety with composition like No. 2. The *Mohsite* of Lévy, still very imperfectly known, is the same or a connected species.

Ilmenite is seldom in sufficient abundance to be used as an ore, and from its extreme infusibility is considered injurious when mixed with other ores, as at Arendal.

343. ISERINE, *Werner;* Magnetic Iron-sand; Trappeisenerz, *Breithaupt;* Hexahedral Iron ore *Mohs.*

Tesseral, in cubes, octahedrons, and dodecahedrons, but generally with rounded edges or in loose grains. Cleavage scarcely, if at all, perceptible. Fracture conchoidal or uneven. H. = 6 — 6·5; G. = 4·7 — 4·9. Colour iron-black; streak black. Acts strongly on the

magnet. In chemical action and composition it resembles ilmenite, but is perhaps only magnetite mixed with peroxide of titanium, or partly replaced by this substance. It occurs in basalt, dolerite, and many volcanic rocks, or in sands formed from their decomposition, as at Iserweise in Bohemia, in the Eifel, Auvergne, near Rome and Naples, and on Teneriffa. The iserine found in many lakes in Pommerania, Brandenburg, and other parts of Northern Germany, must have been derived from a very great distance. The magnetic sand of Cornwall has been classed with this species, and also that found in the bed of the Don in Aberdeenshire, and near the Loch of Tristan on Fetlar in Zetland.

II. Family.—Tin Ore.

344. Cassiterite, *Beudant;* Tin ore, *Allan;* Oxide of Tin, *Phillips;* Zinnstein, *Werner;* Etain oxidé, *Hauy;* Pyramidal Tin ore, *Mohs.*

Tetragonal; P 87° 5′, P∞ 67° 50′; usual combinations ∞P . P; ∞P (*g*) . P (*S*) . ∞P∞ (*l*), or this with P∞ (*P*) (fig. 222); and

Fig. 222.

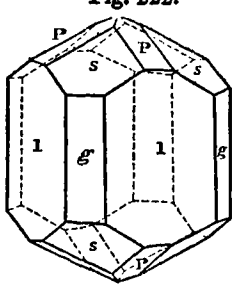
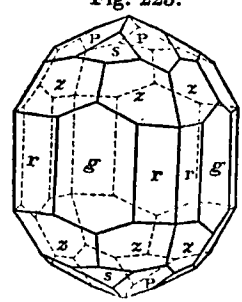


Fig. 223.



also ∞P2 (*r*), and 5P2 (*z*) (fig. 223). The crystals are partly prismatic, partly pyramidal; imbedded or attached, and then combined in druses. Simple crystals, however, are rare, from the remarkable frequency of macles, usually combined by a face of P∞, the chief axes forming an angle of 112° 10′ (figs. 224, 225); and the macles often many times repeated. It also occurs massive in granular aggregates, or finely fibrous (*wood tin*); or in loose angular or rounded fragments and grains (*stream tin*). Cleavage prismatic along ∞P and ∞P∞, rather imperfect; brittle; H. = 6 — 7; G. = 6·3

— 7. Translucent or opaque; lustre adamantine or resinous. When

Fig. 224.

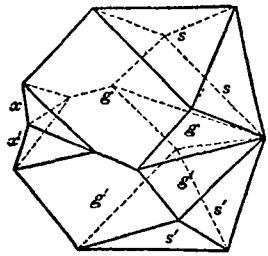
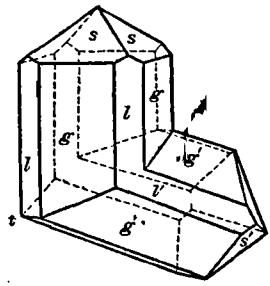


Fig. 225.



pure the colour is white, but usually various shades of grey, yellow, red, brown, and black; rarely wine-yellow or hyacinth red. Streak white, light-grey, or brown. B.B. in the forceps infusible; on charcoal in the inner flame with a strong heat, or more easily with soda, reduced to tin. Not affected by acids. Chem. com. $\dot{S}n$, with 79 tin and 21 oxygen; but often mixed with iron peroxide, or also with silica, manganese peroxide, or tantalic acid. Analyses.

	Tin oxide.	Iron perox.	Mang. perox.	Tantalic acid.	Silica.	Total.	
1	93·6	1.4	0·8	2·4	...	98·2	Berzelius, Finbo near Fahlun.
2	96·26	3·40		...	0·75	100·41	Thomson, Cornwall.
3	91	9	...	...	...	100	Vauquelin, wood tin.
4	95	5	...	...	...	100	Collet Descotils, Mexico.

Klaproth found in a variety from Alternon in Cornwall 77·50 tin, 0·25 iron, 21·50 oxygen, and 0·75 silica. By reducing other varieties in a charcoal crucible in a blast furnace, he found the following proportion of metal:

Brown crystallized, Schlackenwald, ...	72·5	per cent.
Light-brown acicular, Polgooth, Cornwall, ...	75	...
Grey crystallized, St Agnes, Cornwall, ...	74	...
Stream tin, Ladock, Cornwall, ...	76	...
Do. Alternon, Do.	76	...
Wood tin, Cornwall, ...	73	...

Tin ore occurs chiefly in granite, syenite, eurite (felspar) porphyry, and in the crystalline or transition strata. It is found most abundantly in Cornwall, where it has been mined from very ancient times (Herod. iii. 115; Strabo iii. 2), and in the peninsula of Malacca and the island Banca. It is frequently accompanied by rock crystal, fluor-spar, apatite, topaz, tourmaline, wolfram, molybdenite, mispickel,

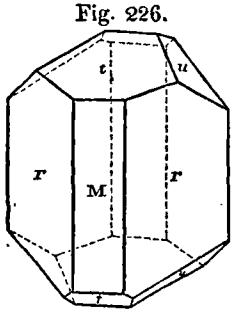
and ores of copper and lead. In Cornwall the tin is usually found in the upper part of the veins, the copper below, and many tin mines abandoned by the Romans have yielded a rich store of copper to the modern miners. In Cornwall fine symmetrical simple crystals, generally of small size, are common; macles are more abundant in the mines of Bohemia and Saxony. The produce of these mines has recently much diminished. In ancient times the mines of Galicia in Spain and Portugal also yielded a considerable amount of tin. This ore is found in less abundance in Silesia, in the Haute Vienne in France, in Greenland, Sweden, Russia, the United States, and other parts both of North and South America. In Cornwall it occasionally forms pseudomorphs after felspar (St Agnes near the Beacon), and also after quartz in the same locality.

This is the only ore used for the production of tin. Being usually disseminated through the rock, the latter must be pounded and washed before the ore can be smelted. The produce of the Cornish Mines is about 100,000 cwts. annually, and that of the East Indian islands nearly as much.

345. WOLFRAM, *Werner*, *Allan*; Tungstate of Iron, *Phillips*; Schéelin ferruginé, *Hauy*; Prismatic Scheel-ore, *Mohs*.

Monoclinohedric; C = 0°, ∞P 101° 5′, ½P∞ 62° 40′, (P∞) 99° 12′. The most common combinations are ∞P (*r*) . ½P∞ (*t*) . ∞P∞ (*M*) . (P∞) (*u*), to which in the large Zinnwald crystals ∞P2 and 2P2 are added; ∞P∞ . ∞P . ∞P2 . 0P . ½P∞ . (P∞), in Ehrenfriedersdorf crystals; and ∞P∞ . ∞P . ∞P2 . (P∞) . P in those from Schlackenwald and Nertschinsk (fig. 226). The crystals appear partly short prismatic, partly broad tabular, with the vertical faces predominating and vertically striated. Macles are rather common, either united by a face of the orthopinakoid when the chief axis is also the twin axis; or by a face of (⅔P∞) when the chief axes are inclined to each other at 120° 52′. It frequently occurs in columnar, laminar, or coarse granular aggregates, united in planes deeply striated. Cleavage, clinodiagonal very perfect; orthodiagonal imperfect; fracture uneven; H. = 5 — 5·5; G. = 7·1 — 7·5. Opaque; lustre metallic-adamantine on the cleavage planes, otherwise resinous. Colour brownish-black; streak reddish-brown to black. Sometimes weak magnetic. B.B. on charcoal fuses to a magnetic globule covered with small crystals. With borax shows reaction for iron; with salt of phosphorus forms

Fig. 226.



in the oxidating flame an iron-green, in the reducing flame a dark-red glass (from tungsten); with soda on platina wire gives the reaction for manganese. Soluble in warm hydrochloric acid, leaving a yellow residue. Chem. com. $(\dot{Fe}, \dot{Mn})\,\dot{W}$. Analyses.

	Tungstic acid.	Iron prot.	Mang. prot.	Silica, &c.	Total.	
1	78·77	18·32	6·22	1·25	104·56	Berzelius, Cumberland.
2	74·67	17·59	5·64	2·10	100·00	Do. Do.
3	75·83*a*	19·24	4·97	...	100	Schaffgotsch, Monte Video, G. 7·544.
4	76·10*a*	19·16	4·74	...	100	Do. Ehrenfriedersdorf.
5	76·40*a*	17·95	6·05	...	100	Do. Chanteloupe (mean of 3), G. 7·437.
6	75·50*a*	9·52	14·98	...	100	Do. Zinnwald (mean of 2), G. 7·191.
7	76·20	19·19	4·48	0·80*b*	100·67	Ebelmen, Limoges (mean of 5).
8	75·99	9·62	13·96	0·48*c*	100·05	Do. Zinnwald (mean of 2).
9	75·56	20·17	3·54	...	99·27	Rammelsberg, Harzgerode, G. 7·143.
10	75·90	9·40	13·90	...	99·20	Kussin, Zinnwald (mean of 3).

(*a*) Tungsten and oxygen; (*b*) magnesia; (*c*) lime.

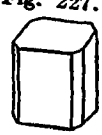
Count Schaffgotsch endeavoured to show that the tungsten in this mineral was not the acid WO^3, but the oxide WO^2, a view which seemed confirmed by the near agreement of its crystallization with that of the columbite according to G. Rose, who referred it to the rhombic system. The analyses of Ebelmen, Rammelsberg and Kussin, however, confirm the old opinion, that it contains the tungstic acid WO^3.

Wolfram occurs with tin ore, forming fine crystals at Altenberg, Geyer and Ehrenfriedersdorf in Saxony, at Schlackenwald and Zinnwald in Bohemia, and in France in quarz veins. In Cornwall, especially near Redruth, it is sometimes so abundant as to render the tin ore wholly valueless. In the Harz it accompanies lead ore, and at Lane's mine in Connecticut it is found in quartz with native bismuth, galena, blende, and other ores. In Rona in the Hebrides it is met with in veins of graphic granite in gneiss; and also occurs in granite near Nertschinsk in the Ural and in Ceylon. At Wheal Maudlin in Cornwall, in Saxony, and in North America, it forms pseudomorphs after scheelite.

346. COLUMBITE, *G. Rose, Dana;* Tantalite, *Phillips* in part; Columbite and Baiérine, *Dufrénoy;* Niobite, *Haidinger.*

Rhombic, ∞P 100° 40′, $2\breve{P}\infty$ 59° 20′. The common combination is $\infty\breve{P}\infty$. ∞P . $0P$. $2\breve{P}\infty$. $\infty\breve{P}\infty$; and the crystals are generally thick tabular, or broad prismatic (fig. 227), from predominance of the brachypinakoid, which is strongly marked with vertical striæ. The macles are united by $2\breve{P}\infty$, and the chief axes are inclined at 59° 20′ to each other. It also occurs massive and foliated or granular. Cleavage, brachydiagonal very distinct, macrodiagonal less so, and basal imperfect. H. = 6; G. = 5·4 — 6·4 (G. = 5·469

Fig. 227.



—5·708 in American varieties; 5·976 — 6·390 in Bavarian). Opaque; lustre metallic adamantine; colour brownish or iron-black; streak reddish-brown or black. B.B. infusible alone; with borax forms a dark blackish-green glass. Not affected by acids until after fusion with potash, or better with the bisulphate of potash. Chem. com. protoxide of iron and protoxide of manganese (Fe, Mn) with a metallic acid, partly niobic, partly tantalic or some similar acid in indefinite proportions. Analyses.

	Niob. acid.	Iron prot.	Mang. prot.	Tin oxide.	Copr. prot.	Lime.	Total.	
1	73·90	15·65	8·00	...	..	...*a*	97·90	Thomson, Middletown, (G.4·8038.)
2	78·83	16·66	4·71	0·29	0·07	0·45*b*	101·23	Schlieper, Do. (G. 5·469 — 5·495).
3	79·62	16·37	4·44	0·47	0·06	trace	100·96	H. Rose, N. America (G. 5·708 in pow-
4	77·30	13·00	9·50	0·50	...	...*c*	100·30	Marignac, Do. [der).
5	79·65	14·00	7·55	0·50	...	...*d*	101·75	Thomson, Bodenmais (G. 6·038).
6	81·07	14·30	3·85	0·45	0·13	trace	99·80	H. Rose, Do. (G. 6·39).
7	81·34	13·89	3·77	0·19	0·10	trace	99·29	Do. Do.
8	79·68	15·10	4·65	0·12	0·12	trace	99·67	Do. Do. (G. 5·7.)
9	80·64	15·33	4·65.	0·10*e*	...	0·21	100·93	Awdejew, Do. (G. 6·021).
10	79·73	14·77	4·77	0·10	1·51	...	100·88	Jacobson, Do. (G. 5·976).
11	80·47	8·50	6·09	...	...	...	100	Hermann, Ilmen, M. G. 5·43 — 5·73).
12	78·60	12·76	4·48*g*	..	0·004	0·75	100·17	Bromeis, Do. (G. 5·461).

(*a*) + 0·35 water; (*b*) + 0·22 nickel oxide; (*c*) + trace of yttria; (*d*) + 0·05 water; (*e*) with copper; (*f*) + 2·44 magnesia, 2·00 yttria, and 0·50 uranium protoxide; (*g*) with yttria, + 3·01 magnesia and 0·56 uranium peroxide.

The streak in Nos. 1, 2, 3, 8, 10 was dark reddish-brown; in No. 9 rather darker; and in Nos. 5, 6, 7 black. The specific gravity of No. 9 was 6·078 in powder.

Hatchett first recognised the peculiar nature of the metallic acid in this mineral in a specimen said to come from Neatneague in North America, but probably from one of the localities mentioned below. This acid was considered identical with that in tantalite till the laborious researches of H. Rose showed its diversity, and that it consisted of two acids resembling the tantalic, but distinct. One is the oxide of a new metal Niobium, but the true character of these substances is still uncertain. The specific gravity of the acid varies with that of the mineral from which it is extracted, being 6·542 from No. 6, 6·13 from No. 9, 5·452 from No. 3, and 4·37 from No. 7, in which H. Rose says it is almost pure niobic acid with traces of pelopic and tungstic acids.

This mineral was first described as monoclinohedric, a view still maintained by Haidinger; but Dana, from whom the above angles are taken, makes it rhombic. The finest crystals occur in a felspar quarry at Middletown in Connecticut, where one was found weighing fourteen pounds. Haddam in Connecticut, and Chesterfield in Massachusets, are other American localities. In Bavaria, it occurs in the granite of the Rabenstein at Zwiesel, near Bodenmais. Thomson distinguished No. 1 under the name of Torrelite.

347. TANTALITE, *Ekeberg, Phillips;* Ferro-tantalite, *Thomson, Dana;* Kimito-tantalite, Prismatic Tantalium ore, *Mohs.*

Rhombic; primitive form, according to Nordenskiöld, a rhombic pyramid of 126°, 112° 30′, and 91° 42′. The crystals prismatic, and lengthened along the chief axis. It also occurs massive in imbedded grains. Cleavage, macrodiagonal, brachydiagonal, and basal, but very indistinct. Fracture conchoidal or uneven. H. = 6 — 6·5; G. = 7·1 — 8. Opaque; lustre semimetallic, inclining to adamantine or resinous. Colour iron-black; streak cinnamon or coffee-brown. B.B. infusible alone, but with borax forms a transparent glass, becoming opaque by flaming. Scarcely affected by acids. Chem. com. protoxides of iron and manganese with tantalic acid. Analyses.

	Tantalic acid.	Iron prot.	Mang. prot.	Tin oxide.	Copper protox. impure.	Lime.	Total.	
1	83·2	7·2	7·4	0·6	...	...	98.4	Berzelius, Kimito, G. 7·30.
2	85·85	12·97	1·61	0·80	...	0·56*a*	102·51	Do. Do.
3	83·44	13·75	1·12	trace	...	...	98 31	Nordenskiöld, Tammela.
4	84·15	14·68	0·90	0·32	1·81	0·07	101·93	Jacobson, Do. G. 7·19
5	84·70	14·29	1·78	0·50	0·04	...	101·31	Brooks, Do.
6	82·93	14·62	trace	1·00	...	...*b*	99·23	Damour, Limoges, G. 7·64 — 765.
7	77·83	8·47	4·88	6·81	0·24	0·50	98·73	Wormum. Tammela, G. 7·187.
8	66·99	6·89	7·16	16·75	...	2·40	100·19	Berzelius, Finbo.
9	65·34	10·50	5·90	8·40	...	1·50*c*	98·76	Do. Broddbo.
10	68·22	8·60	6·43	8·26	...	1·19*d*	99·89	Do. Do.

(*a*) + 0·72 silica; (*b*) + 0·42 silica; (*c*) + 6·12 tungstic acid; (*d*) 6·19 do.

In No. 1, the streak was coffee-brown; in No. 2, cinnamon-brown; and, according to Berzelius, it contained tantalium oxide, not the acid. Nos. 4, 5 were massive, with dark reddish-brown streak. No. 7 was crystallized, with G. = 7·112 — 7·155 in powder. Another specimen, also from Tammela, had G. = 7·476, and in powder, 7·51, whilst Ekeberg raises it to 7·936.

This mineral has been found in seven localities in Finnland, usually in a granite containing oligoclase or albite, and generally with emerald or turmaline. The finest crystals are procured at Härkäsaari, in the parish of Tammela, where it is associated with gigantolite. A massive bluish black variety, with greyish-black streak (No. 6), is found in the pegmatite near Chanteloube in France.

The *Cassiterotantalite* of Hausmann includes the varieties containing tin oxide in considerable amount. They have a lower specific gravity, = 6·2 — 6·5. B.B. with borax easily fusible to a transparent yellow glass, and with soda in the reducing flame yield tin. They are found at Finbo and Broddbo, near Fahlun, with cassiterite, and seem often a mere mixture of this mineral with tantalite.

348. YTTROTANTALITE, *Eheberg*, *Phillips*, *Dufrénoy*; Yttrocolumbite, *Dana*.

Crystallization unknown, but appears in indistinct rectangular, or oblique four-sided, or irregular six-sided prisms; also in imbedded grains, lamellæ, and minute crystalline portions. Cleavage in one direction. Fracture conchoidal or uneven. H. = 5 — 5·5; G. = 5·39 — 5·88. Opaque, or in thin splinters translucent. Berzelius distinguishes (*a*) Black Yttrotantalite, iron-black, with semimetallic lustre, and greenish-grey streak, G. = 5·395; (*b*) Dark or Brown Yttrotantalite, brownish-black, with bright brown streak, and vitreous or resinous lustre; (*c*) Yellow Yttrotantalite, colour yellowish-grey or brown, often stripped or spotted, streak white, lustre resinous or vitreous, G. = 5·88. B.B. infusible alone, but become brown or yellow; and with borax form a transparent yellow glass. Not affected by acids. Chem. com. according to Berzelius, tantalic acid and yttria, but the former partly replaced by tungstic acid, the latter by lime. Analyses.

	Tantalic acid.	Tungstic acid.	Yttria.	Lime.	Uranium peroxide.	Iron perox.	Total.	
1	57·00	8·25	20·25	6·25	0·50	3·50	95·75	Berzelius (black), Ytterby.
2	51·12	2·59	38·52	3·26	1·11	0·55	97·85	Do. (brownish), Do.
3	60·12	1·04	29·78	0·50	6·62	1·16	99·22	Do. (yellow), Do.
4	59·50	1·25	29·90	3·29	3·23	2·72	99·89	Do. (do.) Do.

In Nos. 2, 3, the tungstic acid contained tin; by ignition the black variety lost 5·74 per cent. water; the yellow 4·85 per cent., and of the brown some that retained their colour 2·72, others which became yellow 6·06 per cent. It was first found near Ytterby in Sweden, in flesh-red felspar with gadolinite; and since in the granite veins at Finbo and Kararfvet near Fahlun. Hermann's yttrotantalite (yttroilmenite) from the Ural is the samarskite, see p. 286.

349. EUXENITE, *Scheerér*.

Rhombic probably, the crystals formed by the macropinakoid, two prisms, and two brachydomes. Also occurs compact, with no trace of cleavage. Fracture imperfect conchoidal. H. = 6·5; G. = 4·6. Opaque, or in thin splinters translucent and reddish-brown; lustre metallic vitreous; colour brownish-black; streak reddish-brown. B.B. infusible alone; with borax in the outer flame forms a yellow glass, inclining to brown, and retaining its colour when cold. Not affected by acids. Chem. com. uncertain.

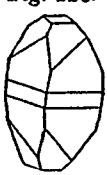
Scheerer found 49·66 tantalic (with some titanic) acid, 7·94 titanic acid, 25·09 yttria, 6·34 protoxide of uranium, 2·18 protoxide of cerium, 0·96 lanthanium oxide, 2·47 lime, 0·29 magnesia, and 3·97 wa-

ter = 98.90; but from the small amount of the fossil, and imperfect means of separating the various constituents, these numbers are mere approximations. The specimen was from Jölster in Northern Bergenhuus in Norway; but it has since been found at Arendal, in rough crystals with lenticular faces. Scheerer now says that it contains no tantalic but niobic acid, and hence is nearer the columbite than the yttrotantalite.

350. FERGUSONITE, *Haidinger*, *Phillips*, *Dufrénoy;* Pyramidal Melan ore, *Mohs.*

Tetragonal, and pyramidal-hemihedric; P = 128° 27′. The usual combination is P . $\frac{1}{2}\infty$P3 . 0P, sometimes also with the half ditetragonal pyramid 3P3 predominating very distinctly (fig. 228). Cleavage, in indistinct traces along P; fracture imperfect conchoidal; brittle. H. = 5·5 — 6; G. = 5·8 — 5·9. Translucent in thin splinters; lustre semimetallic; colour brownish-black; streak pale-brown. B.B. infusible; with borax forms a glass yellow when hot. Chem. com. $\dot{R}^0 \ddot{T}\dot{a}$, where $\dot{R}$ is chiefly yttria with a little protoxide of cerium and zirconia; or, by Hartwall's analysis, 47·75 tantalic acid, 41·91 yttria, 4·68 cerium protoxide, 3·02 zirconia, 1·00 tin oxide, 0·95 uranium peroxide, and 0·34 iron peroxide (= 99·65).

Fig. 228.



It was found by Giesecke imbedded in quartz near Cape Farewell in Greenland, and named after the late R. Ferguson of Raith.

351. SPHENE, *Haüy*, *Phillips*, *Hausmann;* Titanite, *Klaproth;* Menak-Erz, *Werner;* Prismatic Titanium ore, *Mohs.*

Monoclinohedric; C = 85° 6′; ∞P (*l*) 133° 54′, $\frac{5}{9}$P∞ (*x*) 52° 21′, P∞ (*y*) 34° 27′, 0P (*P*), (∞P∞) (*q*), ($\frac{5}{3}$P3) (*M*); and the hemipyramids ($\frac{3}{2}$P2) (*n*) 136° 6′, are in general the predominant forms. The combinations vary extremely, and their apparent diversity is increased by various abnormal formations. The usual aspect of the crystals is either horizontal prismatic when the above or other hemidomes predominate along with 0P; or tabular when $\frac{5}{9}$P∞ or 0P predominate; very often oblique prismatic, from the prevalence of ($\frac{3}{2}$P2); rarely vertical prismatic from ∞P and ∞P∞ (figs. 229, 230). Twin crystals are frequent, united by the basis (*P*), and either in contact or intersecting. It also occurs imbedded, in granular or foliated masses. Cleavage, in many varieties prismatic along ∞P; in others, clinodomatic along (P∞) (*r*) 113° 30′, imperfect. H. = 5 — 5·5; G. = 3·4 — 3·6. Semitransparent or opaque; lustre adamantine, or often resinous; colour brown, yellow, or green, and

sometimes varying on the same crystal. B.B. slightly intumesces,

Fig. 229.

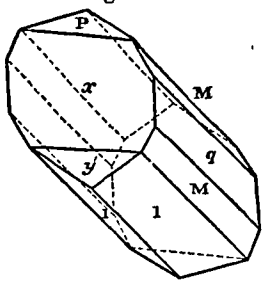
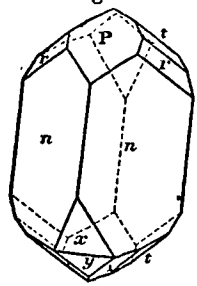


Fig. 230.



and fuses on the edges to a dark glass. With borax forms a transparent yellow glass; with salt of phosphorus in the reducing flame, especially with tin, shows the reaction for titanic acid. Imperfectly soluble in hydrochloric, wholly in sulphuric acid, which dissolves the titanic acid, and forms sulphate of lime. Chem. com., according to H. Rose, $\dot{C}a^2\,\dot{S}i + \dot{T}i^2\,\dot{S}i$, with 31·3 silica, 40·4 titanic acid, and 28·3 lime, part of the last being replaced by iron protoxide in the brown varieties. Berzelius, on the other hand, considers that the whole silica will combine with lime as the far stronger base, and hence gives the formula $2\,\dot{C}a\,\dot{S}i + \dot{C}a\,\dot{T}i^3$. Analyses.

	Silica.	Titan. acid.	Lime.	Iron prot.	Mang. prot.	Total.	
1	32·52	43·21	24·18	...	...	99·91	Fuchs, Schwarzenstein, G. 3·44, yellow.
2	32·29	41·58	26·61	0·96	...	101·44	H. Rose, Zillerthal, G. 3·535, greenish.
3	30·63	42·56	25·00	3·93	...	102·12	Brooks, Passau, brown.
4	31·20	40·92	22·25	5·06	...	99·43	Rosales, Arendal, Do.
5	29·8	43·0	23·6	trace	2·9	99·3	Delesse, St Marcel, greenovite.
6	30·4	42·0	24·3	trace	3·6	100·3	Do. Do. Do.
7	32·26	38·57	27·65	0·76*a*	0·76*a*	100	Marignac, Do. Do.

(*a*) Peroxide.

Sphene occurs chiefly disseminated in the crystalline strata, and in igneous rocks of all ages, but especially in some syenites. It is also found in beds with magnetite, copper pyrites, and other ores; and in veins with rock crystal, adularia, albite, asbestus, talc, and chlorite, the last often covering or penetrating the crystals. Fine specimens of sphene are found in many parts of the Alps, as in Dauphiné near Mont Blanc, on St Gotthardt, at Dissentis in Graubündten, at Schwarzenstein, and other parts of Tyrol. In the Ural it occurs near Slatoust. Common sphene is found in granitic or hornblendic rocks in the iron mines at Arendal, where one yellow tabular crystal was 6 inches long and 5 broad; also in various parts of Sweden, in Saxony near Dresden, in Moravia and Thuringia, all in syenite. Small crys-

tals are occasionally met with in syenite at Criffel and near Strontian in Scotland. It occurs in clinkstone at Aussig and Teplitz; in basalt near Wessel in Bohemia; and at Lake Laach in ejected blocks with glassy felspar. It is also common on Vesuvius, and in France, Greece, Brazil, the United States, and Greenland.

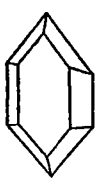
The *Greenovite* from St Marcel in Piedmont is merely sphene with part of the lime replaced by protoxide of manganese, giving it a flesh-red colour, and reddish streak. Dufrénoy makes it a distinct species, and says that it differs in crystallization, but the variation is very small, and scarcely essential.

352. BROOKITE, *Lévy.*

Rhombic; P with polar edges 135° 46′ and 101° 37′, ∞P 100°.

The usual combination is $\breve{P}\infty . \infty P . P$ (fig. 231). More complex crystals occur, but the brachypinakoid always greatly predominates, giving them a tabular aspect. Cleavage, macrodiagonal. H. = 5·5 — 6; G. = 4·128 — 4·167. Opaque or translucent; lustre metallic adamantine; colour yellowish, reddish, or hair-brown; streak yellowish-white. B.B. infusible; with salt of phosphorus forms a brownish-yellow glass. Chem. com., according to H. Rose, $\dot{T}i$ or titanic acid, with, at most, 1·4 per cent. peroxide of iron.

Fig. 231.



Brookite was long considered a variety of rutile, with which, and anatase, it agrees in chemical composition, but differs from it in its lower specific gravity, and also in crystallization. The gravity, however, increases on ignition, having risen to 4·197 in some crystals heated for 45 minutes over a spirit lamp. It was first found with anatase at Bourg d'Oisans in Dauphiné, and since at Tête-Noire near Chamouni, and in the Steinthal near Amstäg in the Canton Uri. The finest crystals, sometimes half an inch in diameter, occur with albite and quartz on Snowdon and near Tremaddoc in North Wales.

353. RUTILE; Rutil, Nigrine, *Werner;* Peritomous Titanium ore, *Mohs.*

Tetragonal; P 84° 40′, P∞ 65° 34′; the usual combinations are ∞P . ∞P∞ . P, and ∞P3 . P. The crystals (fig. 232) always prismatic, often acicular or capillary, occur attached or imbedded. Macles are very common (like fig. 225, p. 407 above), united by a face of P∞, and hence with their chief axes inclined at 114° 26′. These are often repeated, forming a reticulated mass of acicular and capillary crystals (*Sagenite*). It is also found massive and imbedded in crystalline or granular aggregates. Cleavage,

Fig. 232.

prismatic along ∞P, and ∞P∞ perfect; fracture conchoidal or uneven; H. = 6 — 6·5; G. = 4·2 — 4·3 Translucent or opaque; lustre metallic adamantine; colour reddish-brown to dark blood-red and cochineal-red, also yellowish-brown to ochre-yellow and black (*Nigrine*); streak yellowish-brown. Acquires negative electricity by friction. B.B. unchanged alone; with borax in the oxidating flame forms a greenish, in the reducing flame a dirty violet-coloured glass. Not affected by acids. Chem. com. titanic acid, $\dot{T}i$, with 60·3 titanium and 39·7 oxygen, sometimes with 1·5 per cent. peroxide of iron (H. Rose and Damour). In a black variety from Freiberg, becoming blood-red by ignition, Kersten found 2·4 per cent. of peroxide of iron and magnetic iron, the latter separable from the pulverized mineral by a magnet. Kersten conjectures that the black colour may be caused by peroxide of titanium. In rutile from Käring-Bricka in Westmanland, Ekeberg and Vauquelin found chrome.

Rutile occurs chiefly in mica and chlorite slates, in gneiss and granite. It shows a strong tendency to associate with silica; its long acicular prisms often investing the surface of rock crystal, or penetrating it in every direction. Fine crystals occur in many parts of the Alps; at Buitrago in Spain, St Yrieux near Limoges, Rosenau in Hungary; also in the Ural, Brazil, and North America. It occurs in gneiss near Brevig, and it has been said in the magnetic iron ore at Arendal, but probably erroneously. It is common in many parts of the Scottish Highlands, and fine large prisms are found on Crianlarich in Perthshire. It is used in painting porcelain to produce a yellow colour.

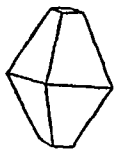
Nigrine is merely the black variety, sometimes mixed with peroxide of iron or manganese. It occurs in many igneous rocks, or in the sands derived from them, as in the gold washings of Ohlapian in Siebenburg. *Warwickite* of Shepard, dark hair-brown or iron-grey, G. = 3 — 3·29, and said to crystallize in oblique rhombic prisms, contains 64·71 titanium, 7·14 iron, 0·80 yttrium, 27·33 fluorine with trace of aluminium (= 99·98), *Shepard*. Berzelius considered it an impure rutile mixed with titanite, and Mr Hunt finds that it contains no fluorine, but is a silicate and titanate of iron, magnesia and alumina, with 7 per cent. water. It is found near Edenville in New York.

354. ANATASE, *Hauy*; Octaedrite, *Saussure*, *Werner*; Pyramidal Titanium ore, *Mohs*.

Tetragonal; P 136° 47′ (*Phillips*). The crystals usually formed of P, P . 0P (fig. 233), or P . ½P, are attached singly, or loose. Cleavage, basal and pyramidal along P, both perfect. Brittle; H. = 5·5 — 6;

G. = 3·83 — 3·93. Semitransparent or opaque; lustre metallic-adamantine; colour indigo-blue, sometimes almost black, hyacinth-red, honey-yellow or brown, rarely colourless; streak white. Becomes negative electric by friction. B.B. infusible, but when heated shows a sudden gleam of reddish-yellow light (*Brewster*); with borax it forms a glass which in the reducing flame is yellow, but at length becomes violet-blue; only soluble in warm concentrated sulphuric acid. Chem. com. titanic acid with a little peroxide of iron, or rarely tin oxide (Vauquelin and H. Rose). In a specimen from Brazil Damour found 98·36 titanic acid, 1·11 peroxide of iron, and 0·20 tin oxide (= 99·67).

Fig. 233.



Crystals from Brazil, with a specific gravity of 3·927 and 3·917, after 45 minutes' exposure to a red heat, had G. = 4·117 and 4·125; and after three hours in a strong red heat, G. = 4·166 and 4·161, or when thoroughly freed from extraneous matter, 4·233 and 4·251. Thus anatase first attains the gravity of brookite, and then both that of rutile, so that these three minerals are only distinguished permanently by their very distinct crystallization.

Anatase is also remarkable for its electric properties, which first led Hauy to suspect its metallic nature. Hausmann and Henrici, in a blue crystal with yellow middle from Dauphiné, observed a complete and immediate discharge of the electricity with sparks on contact with the conducting wire; in a yellow transparent crystal from Brazil there was almost no discharge, even after a considerable interval, and no sparks. In two other crystals, partly of a blue colour, the discharge was immediate, with a strong spark. In rutile the discharge was very imperfect.

Anatase occurs in granite, diorite, chlorite slate, mica slate, and transition strata, in druses or small irregular veins, often with quartz, felspar, albite, axinite, garnet, and chlorite. The finest crystals are from the Alps, as near St Cristophe in Dauphiné, the Maggia valley in the canton Tessin, in the Valois and Salzburg. It is found in the Fichtelgebirge, in Spain, at Slidre in Norway (not at Arendal), and in the Ural. Fine crystals occur in Brazil in Minas Geraes in the sand of a brook near Itabiro de Matto Dentro, with diamonds, for which they have sometimes been mistaken. It also occurs in Cornwall in granite.

354. PECHURANE, *Hausmann;* Uranpecherz, *Werner;* Pitch-Blende, *Phillips;* Uranium ore, *Allan;* Uncleavable Uranium ore, *Mohs.*

Amorphous. Generally massive and disseminated, also reniform

with a columnar or curved lamellar structure. Fracture conchoidal or uneven and polished. H. = 5·5 ; G. = 6·468 or sometimes 7·9 — 8. Opaque ; lustre imperfect metallic or resinous ; colour greyish, greenish, or brownish-black ; streak greenish-black. B.B. infusible alone ; with borax and salt of phosphorus it forms in the oxidating flame a yellow, in the reducing flame a green glass. Not affected by hydrochloric acid, but is easily soluble in warm nitric or nitro-chloric acid. Chem. com. proto-peroxide of uranium, or $\dot{U}\ddot{U}$, with 84·78 uranium and 15·22 oxygen, but with many impurities. Analyses.

	Uranium.	Lead.	Iron.	Manganese	Lime.	Magnesia.	Silica.	Watr.	Arsenic.	Total.
1	72·00*a*	...	...	0·05*a*	6·00	...	4·26	14·75	traced	99·36
2	79·15*c*	6·20	3·03	...	2·81	0·46	5·30	0·36	1·13*e*	99·09
3	75·94*g*	4·22	3·10*b*	0·82*b*	5·24	2·07	3·48	1·85	8·64*f*	100·89

(*a*) Peroxide; (*b*) protoxide; (*c*) proto-peroxide; (*d*) + 2·30 phosphoric acid, with trace of fluoric acid ; (*e*) + 0·65 bismuth, with lead and copper ; (*f*) + 0·60 sulphur, 0·25 soda, and 3·32 carbonic acid ; (*g*) green oxide.

(1) Kersten, hyacinth-red pechuran from Johann-Georgenstadt; (2) Rammelsberg, from the Tanne mine, Joachimsthal ; (3) Ebelmen, Joachimsthal.

Vanadium has been found by Wöhler and Svanberg in some varieties, and by Kersten in that from Johann-Georgenstadt along with selenium. This variety is the *Gummierz* of Breithaupt, with H. = 2·5 — 3 ; G. = 3·9 — 4·2. The *Pittinerz* of Breithaupt from the same locality has an olive-green streak, H. = 3·0 — 3·5 ; G. = 4·8 — 5·0. These may perhaps be distinct species, but the impurity and amorphous nature of the mineral renders this uncertain. Besides the above places, pechurane is found at Wiesenthal, Marienberg, Annaberg, and Schneeberg in Saxony, at Przibram in Bohemia, Rezbanya in Hungary, Middletown and Haddam in Connecticut, and at Tincroft and Tol Carne mines near Redruth in Cornwall. It is used in porcelain painting, the colour being a fine orange in the enamelling fire, and black in that in which the porcelain is baked.

355. PLATTNERITE, *Haidinger ;* Schwerbleierz, *Breithaupt ;* Superoxyd of Lead, *Dana.*

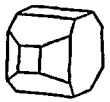
Hexagonal, but dimensions unknown. The crystals are composed of $\infty P . 0P . P$. Cleavage in several directions, but indistinct ; fracture uneven, brittle. G. = 9·39 — 9·44. Opaque ; lustre metallic adamantine ; colour iron black ; streak brown. Chem. com., according to Plattner, $\dot{P}b$, with 86·2 lead and 13·8 oxygen, but with a trace of sulphuric acid. Probably from the Leadhills in Scotland.

III. Family. Manganese Ores.

356. Pyrolusite, *Haidinger*, *Allan;* Grauer Braunstein, *Werner*, in part; Manganese oxidé, *Hauy*, in part; Prismatic Manganese ore, *Mohs*.

Rhombic; ∞P 93° 40′ (also 99° 36′, *Breithaupt*). The crystals are usually short prismatic, and either bounded on the ends by flat domes, or divided into numerous points (fig. 234). Other crystals are thin tabular. Generally it occurs massive and disseminated, or in botryoidal, reniform masses, with a radiating columnar or fibrous structure; or in confused fibrous, earthy, or compact varieties. Cleavage, prismatic along ∞P, and brachydiagonal; rather brittle or friable; H. = 2 — 2·5 (lower when fibrous or earthy); G. = 4·7 — 5. Opaque; lustre semimetallic, or silky when fibrous; colour dark steel-grey, bluish, or iron-black; streak black and soiling. B.B. infusible, but, strongly ignited on charcoal, it loses 12 per cent. oxygen, and is converted into the brown protoperoxide. With borax and salt of phosphorus it shows reaction for manganese. Soluble in hydrochloric acid, with large evolution of chlorine. Chem. com. $\dot{M}n$, with 63·6 manganese and 36·4 oxygen. Analyses.

Fig. 234.



	Mang. proto-perox.	Oxy-gen.	Baryta.	Watr.	Silica, &c.	Total.	
1	83·56	14·58	...	1·86	...	100	Arfvedson, Undenaes.
2	84·06	11·78	0·53	1·12	0·51	100	Turner, Elgersburg.
3	85·62	11·60	0·66	1·57	0·55	100	Do. Ihlefeld ?
4	87·0	11·6	1·2	5·8	0·8*a*	103·3	Scheffler, Ilmenau.

(*a*) + 1·3 iron peroxide, 0·3 lime, and 0·3 alumina.

Pyrolusite was formerly confounded with manganite, but differs in crystallization, and in containing no water. It is best distinguished by the colour of the streak, and its softness, often so great as to soil the fingers. It occurs chiefly in beds in gneiss, clayslate, porphyry, and the older rocks, or in veins often with calc-spar, heavy spar, and ores of iron and manganese. It sometimes has been produced by the decomposition of the latter; and crystals of manganite are found only partially converted into pyrolusite. It is also a common pseudomorph after calc-spar.

This ore is extensively wrought in many places, as at Ilmenau and Elgersburg in Thuringia, at Vorderehrensdorf in Moravia, and in dolomite near Giessen. Fine crystals are obtained at Ihlefeld, and near Goslar in the Harz, and at Johann-Georgestadt in Saxony. It also

occurs in various parts of Westphalia, Bohemia, France, Hungary, and Siebenburg, and in Brazil near Villa Ricca. In Britain it is found in Cornwall and Devon.

Pyrolusite gives off 10 or 11 per cent. oxygen at a red heat, and hence is employed to remove the brown and green tints in glass, arising from carbonaceous matter or protoxide of iron. This property has given occasion to its name, and the French, for the same reason, fancifully term it *le savon des verriers*. It is also used for producing oxygen, chlorine, and chloride of lime, in painting glass and enamel work, for glazing brown pottery, and colouring certain of the finer varieties, its softness and want of cohesion proving advantageous for many of these purposes. Like other ores of manganese, it is thought beneficial when mixed with iron ores, both counteracting the bad effects of the heavy spar they may contain, and improving the quality of the iron and steel.

Varvacite of R. Phillips, found in Warwickshire, seems a result of the tendency of manganite to exchange the water for oxygen, and is intermediate between it and pyrolusite. Phillips found in it 63·3 manganese, 31·7 oxygen, and 5 water. It chiefly occurs in pseudomorphs after scalenohedrons, R^3, of calc-spar; but also in crystals with $\infty P = 99° 36'$, according to Breithaupt, or in columnar and fibrous masses. H. = 2·5 — 3; G. = 4·5 — 4·6. Colour iron-black to steel-grey, with black streak, and semimetallic lustre. Turner analyzed a similar mineral from Ihlefeld in the Harz.

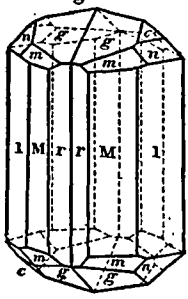
357. POLIANITE, *Breithaupt.*

Rhombic; ∞P 92° 52′, $\breve{P}\infty$ 118°. The crystals of these forms with $0P$, $\infty\breve{P}\infty$, $\infty\bar{P}\infty$, and two macroprisms, are generally short prismatic and vertically striated. It also forms granular masses. Cleavage, brachydiagonal perfect. H. = 6·5 — 7; G. = 4·84 — 4·88. Opaque; lustre weak metallic; colour light steel-grey. B.B. acts like pure hyperoxide of manganese. Chem. com $\dot{M}n$, or identical with pyrolusite. In a specimen from Maria-Theresa Zeche near Platten in Bohemia, Plattner found 87·27 protoperoxide of manganese, 12·11 oxygen, 0·17 iron peroxide and alumina, 0·13 quartz, and 0·32 water (= 100). This gives 99·38 per cent. hyperoxide of manganese, and Rammelsberg has confirmed its accuracy. Hence Breithaupt is probably correct in considering this as the original hyperoxide of manganese, whilst pyrolusite is a mere product of the decomposition (oxidation) of other ores mixed with water and various impurities. Other localities of polianite are Schneeberg, Geyer, and Johann-Georgenstadt in Saxony, and the Eisernen Haardt in Siegen.

358. MANGANITE, *Haidinger;* Grauer Braunstein, *Werner* in part; Grey Oxide of Manganese, *Phillips;* Grey Manganese, *Allan;* Prismatoidal Manganese ore, *Mohs.*

Rhombic, sometimes hemihedric; ∞P (*M*) 99° 40′; ∞P̆ 2 (*l*) 118° 42′, ∞P̆$\frac{1}{3}$ 103°. 23′, P̄∞ (*d*) 114° 19′. The crystals always prismatic, from the predominance of many prisms, are generally bounded at the ends by P̄∞, P̄3 (*g*), or 0P (fig. 235), with ∞P̄2 (*r*), 2P (*m*), and 2P̆2 (*n*). They are marked by strong vertical striæ, and very often grouped in bundles (a kind of macle), or united in druses. It also forms radiating, columnar, or fibrous, and more rarely granular aggregates. Cleavage, brachydiagonal very perfect, basal and prismatic along ∞P less perfect. Rather brittle. H. = 3·5 — 4; G. = 4·3 — 4·4. Opaque; lustre imperfect metallic; colour dark steel-grey to iron-black, or often brownish-black and tarnished; streak brown. B.B. acts like manganese peroxide, and is infusible; with borax in small quantity forms a violet-blue glass. Soluble in warm concentrated hydrochloric acid, and slightly in concentrated sulphuric acid, which acquires a red tinge from the powder in a few days. Chem. com. M̈n + Ḣ, with 89·9 manganese peroxide and 10·1 water, closely agreeing with the analyses:—

Fig. 235.



	Manganese.	Oxygen.	Water.	
1.	89·92		10·08	= 100, Arfvedson, Undenaes.
2.	62·86	27·64	9·50	= 100, L. Gmelin, Ihlefeld.
3.	62·72	27·18	10·10	= 100, Turner, Do. (m. of 2).

Manganite occurs abundantly in veins in porphyry with calcspar and barytes at Ihlefeld in the Harz; also in several parts of Thuringia. In irregular veins in gneiss at Granan near Aberdeen, Christiansand in Norway, Undenaes in Sweden; in France, Nova Scotia, and other places. It is used for the same purposes as the pyrolusite, but is less valuable from giving off less oxygen. When changing to pyrolusite, the sp. gr. of manganite rises to 4·5 — 4·8; and the streak becomes black.

359. HAUSMANNITE, *Haidinger;* Glanzbraunstein, *Hausmann;* Pyramidal Manganese ore, *Mohs.*

Tetragonal; P 117° 54′, P∞ 99° 11′. The usual forms are P and P . $\frac{1}{2}$P, and the crystals, always pyramidal, are grouped in druses.

Macles are common, united by a face of P∞ (fig. 81, p. 41 above), and often symmetrically repeated on all the four polar edges of a central crystal. It also forms granular aggregates. Cleavage, basal rather perfect; less distinct along P and P∞. Fracture uneven. H. = 5·5; G. = 4·7 — 4·8. Opaque; lustre strong metallic; colour iron-black; streak brown. B.B. acts like peroxide of manganese. Soluble in hydrochloric acid with escape of chlorine. The powder colours concentrated sulphuric acid bright-red in a short time. Chem. com. $\dot{M}n + \ddot{M}n$, with 31 protoxide and 69 peroxide of manganese, or 72·4 manganese and 27·6 oxygen. Analyses.

	Manganese.*	Oxygen.	Baryta.	Silica.	Watr.	Total.	
1	98·90	0·22	0·11	0·34	0·43	100	Turner, Ihlefeld, Harz.
2	92·49	7·00	0·15	...	...	99·64	Rammelsberg, Oehrenstock near Ilmenau.

* In (1) protoperoxide; in (2) protoxide.

Hausmannite is rather rare, but occurs with other manganese ores at the above localities, and, it is said, at Leisa near Marburg and Schneeberg in the Erzgebirge. Allan adds Framont in Alsace, and Dana, Lebanon in Pennsylvania.

360. BRAUNITE, *Haidinger*, *Phillips*; Hartbraunstein, *Hausmann*; Brachytype Manganese Ore, *Mohs*.

Tetragonal; P 108° 39′, consequently almost an octahedron. The usual forms are P and P . 0P. The crystals often very small, and united in druses or granular aggregates. Cleavage, pyramidal along P rather perfect. Fracture uneven; brittle. H. = 6 — 6·5; G. = 4·818. Opaque; lustre imperfect metallic; colour and streak dark brownish-black. B.B. infusible alone; with fluxes shows reaction for manganese. Soluble in hydrochloric acid, evolving chlorine. Chem. com. peroxide of manganese $\ddot{M}n$, with 70 manganese and 30 oxygen; or by Turner's analysis of a variety from Elgersburg, 67·44 manganese, 29·35 oxygen, 2·62 baryta, 0·95 water, and trace of silica (= 100).

It occurs at Elgersburg, Oehrenstock, and Friedrichsroda in Thuringia in quartzose porphyry; and also near Ihlefeld, Schmalkald, Leimbach in Mansfeld, and Neuenkirchen in Westphalia.

Marceline of Beudant from St Marcel was considered distinct, but Descloiseaux has found its crystallization to agree with braunite. The *Heterocline* of Breithaupt, from the same locality, said to form monoclinohedric pyramids with faces meeting at 109° 36′, is very similar. It is iron-black, with brownish-black streak. G. = 4·652; H. = 5. The following are analyses of these minerals.

	Mang. perox.	Iron perox.	Silica.	Lime.	Magnesia, &c.	Total.	
1	68·63*a*	11·40	10·24	1·14	0·26	98·96	Damour, Marceline, G. 4·75.
2	85·97	3·39	10·16	0·61	0·44 *b*	100·47	Ewreinoff, Heterocline.
3	75·80	4·14	15·17	...	2·80 *c*	97·91	Berzelius, *Do.*

(*a*) Protoxide + 7·20 oxygen ; (*b*) potash ; (*c*) alumina.

Berzelius gives $\dot{M}n^3\ddot{S}i$ for the substance he analyzed; but they seem rather impure mixtures of braunite ; compare Rhodonite, p. 211

361. PSILOMELANE, *Haidinger*, *Phillips;* Schwarzeisenstein, *Werner;* Uncleavable Manganese Ore, *Mohs.*

Cryptocrystalline or amorphous. It forms botryoidal, reniform, or stalactitic masses, with smooth, rough, or granular surfaces, and rarely showing traces of a fibrous texture, more often only a foliated structure. It also occurs massive and disseminated. Fracture conchoidal or uneven. H. = 5·5 — 6 ; G. = 4·1 — 4·2. Opaque ; lustre dull or glimmering ; colour iron-black or bluish-black ; streak brownish black and glistening. In the closed tube yields water. B.B. infusible alone ; with fluxes acts like peroxide of manganese. The powder colours concentrated sulphuric acid red ; and the varieties containing barytes furnish a copious white deposit. Analyses.

	Mang. proto-perox.	Oxy-gen.	Ba-ryta.	Pot-ash.	Copper protox.	Silica.	Watr.	Total.	
1	69·80	7·36	16·36	...	..	0·26	6·22	100	Turner, Schneeberg.
2	70·97	7·26	16·69	...	...	0·95	4·13	100	Do. Romanèche.
3	81·8	9·5	...	4·5	...	...	4·2	100	Fuchs, Baireuth.
4	81·36	9·18	...	3·04	0·96	0·54	3·39*b*	100·61	Rammelsberg, Horhausen.
5	70·64*a*	14·18	6·55	4·05	...	0·60	1·67*c*	99·47	Ebelmen, Gy, Haute-Saone.
6	77·23*a*	15·62	0·12	5·29	0·40	0·52	... *d*	100·29	Clausbruch, Ilmenau.
7	83·3	9·8	5·8	...	...	1·7	4·3 *e*	99·1	Scheffler, *Do.*
8	70·17*a*	15·16	8·08	2·62	0·30	0·90	1·43*f*	100	Rammelsberg, Heidelberg.

(*a*) Protoxide ; (*b*) + 1·43 iron peroxide, 0·38 lime, and 0·32 soda and magnesia ; (*c*) + 1·05 magnesia and 0·77 iron peroxide ; (*d*) + 0·91 lime ; (*e*) + 1·8 lime, 2·1 alumina, and 0·3 iron peroxide ; (*f*) + 0·60 lime, 0·21 magnesia, and 0·54 cobalt protoxide.

Turner considered psilomelane as a compound of peroxide of manganese and baryta, the hyperoxide of manganese arising in a mixture of pyrolusite. Rammelsberg again gives the general formula $\dot{M}n\ddot{M}n + \dot{H}$ or $3\ \dot{H}$, with part of the protoxide replaced by potash or baryta (so that potash and baryta psilomelanes might be distinguished), or by magnesia and protoxides of copper or cobalt. On this view a great part of the hyperoxide is merely mixed. Thus, in

	Manganese protoxide.	Manganese-hyperoxide combined.	mixed.
No. 1 ...	10·53 ...	44·21 ...	22·41
No. 4 ...	9·50 ...	32·72 ...	48·30
No. 6 ...	6·87 ...	30·24 ...	56·55
No. 8 ...	4·68 ...	30·02 ...	50·17

It seems thus rather a mixture than a simple mineral. Besides the above localities, psilomelane occurs in Devonshire, Cornwall, Vermont in North America, and many other places, generally with ores of manganese.

362. CREDNERITE, *N.;* Mangankupferoxyd, *Hausmann.*

Monoclinohedric; dimensions unknown. Occurs in crystalline granular, foliated aggregates; sometimes in concentric layers with pyrolusite and hausmannite. Cleavage, basal very distinct, prismatic, along the sides of a clinorhombic prism imperfect; H. = 4·5 — 5; G. = 4·89 — 5·07. Opaque; lustre metallic; colour iron-black; streak brownish-black. In the closed tube gives no water. B.B. infusible, but exfoliates; with soda yields copper; with borax in the inner flame forms a glass first green, then copper-red and enamel-like, and at length, especially with tin, colourless and transparent. Nitric acid dissolves the copper protoxide. In nitrochloric acid it forms easily a green solution. Chem. com. nearly 3 $\dot{C}u$ + $\dot{M}n\ \ddot{M}n$, or, by Credner's analysis, 43·85 copper protoxide, and 55·73 protoperoxide of manganese (= 99·58). It occurs at Friedrichsroda in Thuringia with ores of manganese, the volborthite and earthy malachite.

363. CUPREOUS MANGANESE, *Phillips;* Kupfermanganerz, *Breithaupt;* Uncleavable Brithyne-Allophane, *Mohs.*

Amorphous; botryoidal, stalactitic, or encrusting. Fracture conchoidal or earthy; rather brittle or friable; H. = 3·5 or less; G. = 3·1 — 3·2. Opaque; vitreous lustre; colour black, inclining to brown or blue; streak similar. Give off much water in the closed tube. B.B. fusible, and yield copper; with fluxes show reaction for copper and manganese. Chem. com. $(\dot{M}n\ \dot{C}u)\ \ddot{M}n^2 + 2\ \dot{H}$, *Rammelsberg.* Analyses.

	Mang. perox.	Oxygen.	Copper protox.	Iron perox.	Baryta.	Lime.	Watr.	Silica.	Potash.	Total.	
1	74·10	...	4·80	0·12	...	...	20·10	0·30	...*a*	100·47	Kersten.
2	49·99*b*	8·91	14·67	4·70	1·64	2·25	14·46	2·74	0·52*c*	101·06	Rammelsberg.
3	53·22*b*	9·14	16·85	1·88	1·69	2·85	16·94	...	0·64*d*	103·34	Böttger.
4	30·05	...	11·51	28·29	...	...	29·45	...	...	100	Du Menil.

(*a*) + 1·05 gypsum; (*b*) protoxide; (*c*) + 0·69 magnesia and 0·49 protoxides of cobalt and nickel; (*d*) + 0·14 protoxide of cobalt and nickel.

No. 1 is from Schlackenwald; Nos. 2, 8 from Camsdorf near Saalfeld; No. 4 the *Black Copper* of Phillips (Kupferschwärze, *Werner*) from Lauterberg in the Harz. They are evidently very impure mixtures, and are rather the results of decomposition than distinct species. Similar substances are common in many of the copper mines in Cornwall, the Harz, Silesia, and Siberia.

364. EARTHY-COBALT, *Phillips;* Schwarzer Erdkobalt, *Werner;* Uncleavable Psylomelane-Graphite, *Mohs.*

Amorphous, reniform, stalactitic, or investing, also massive and disseminated. Fracture conchoidal or uneven; sectile; H. = 1 — 1·5; G. = 2·1 — 2·2. Opaque; lustre dull or glimmering; bluish or brownish-black; streak black, shining, and leaves a mark. It gives out water in the closed tube. B.B. infusible alone, but colours borax glass violet in the outer, smalt-blue in the inner flame. Chem. com. (Ċo, Cu) $\dot{M}n^2$ + 4 Ḣ according to Rammelsberg, who found 40·05 manganese protoxide, 9·47 oxygen, 19·45 cobalt protoxide, 4·35 copper protoxide, 4·56 iron peroxide, 0·50 baryta, 0·37 potash, and 21·24 water (= 99·94) in a very pure variety from Camsdorf near Saalfeld. He considers the iron peroxide with 0·52 water as a mixture of limonite.

The analyses of Klaproth and Dobreiner were imperfect, and the mineral seems rarely pure, being probably a mere product of decomposition. It occurs also at Glücksbrun in Thuringia, Riechelsdorf in Hessia, in the Lauzitz; the Ural; and at Alderley Edge in Cheshire in sandstone, with lead and copper. It is only used in the preparation of smalt. The *Horncobalt* from Siegen seems a mixture of this mineral with quarz.

365. WAD, *Karsten, Allan;* Earthy Manganese, *Phillips;* Manganschaum, *Hausmann;* Schaumartiger Wad-Graphit, *Mohs.*

Massive; and forming reniform, stalactitic, or arborescent froth-like crusts, or masses sometimes with curved laminar divisions. Fracture conchoidal or even, with a fine, scaly, earthy, or compact surface; very soft and sectile, but some varieties brittle, with H. = 3; G. = 2·3 — 3·7; but from its loose porous texture feels very light, and even swims on water. Opaque; lustre semimetallic, and shining or dull; colour and streak brown or black. It gives out water in the closed tube. B.B. acts like peroxide of manganese. Almost wholly soluble in hydrochloric acid. Chem. com. very uncertain, but on the whole Ṁn (Ċa, Ḃa, Ḳ) $\dot{M}n^3$ + 3 Ḣ, mixed with Ṁn, *Rammelsberg.* Analyses, next page.

	Mang. prot.	Oxy-gen.	Watr.	Bary-tes.	Lime.	Iron perox.	Silica, &c.	Total.	
1	79·12*a*	8·32	10·66	1·40	...	...	...	100	Turner, Upton Pyne, Devon.
2	38·59*b*	...	10·29	5·40	...	52·34	2·74*c*	109·36	Do. Derbyshire
3	62·4	12·8	15·8	...	...	6 0	3·0 *d*	100	Berthier, Groroi.
4	68·9	11·7	12·4	...	...	...	7·0 *d*	100	Do. Vicdessos.
5	66·5	12·1	9·8	8·1	...	1·0	2·5	100	Scheffler, Ilmenau.
6	67·50	13·48	10·30	0 36	4·22	1·01	0·47*e*	100	Rammelsberg, Harz.
7	82·51*b*	...	5·58	...	1·91	0·77	1·43*f*	99·19	Igelström, Westgothland.

(*a*) Protoperoxide; (*b*) peroxide; (*c*) earthy matter; (*d*) alumina; (*e*) + 3·66 potash; (*f*) + 6·30 alumina and 0·69 magnesia.

Wad is often a result of the decomposition of carbonate of iron or other ores, and is a very common mineral, though rarely occurring in large masses. It is found in beds, veins, and fissures, or colouring the surface, and forming dendritic delineations on rocks of various kinds. Some of its chief localities are Elbingerode and Iberg in the Harz; Kemlas and Arzberg in Franconia; Siegen, Nassau, Piedmont, and Vicdessos and other places in France. The ochrey variety occurs near Exeter in Devonshire and in Cornwall. The variety from Groroi in Mayenne is the *Groroilite* of Berthier, but is not a distinct species.

Wad is used chiefly as a coarse pigment in oil painting; also for colouring and glazing pottery, and in the manufacture of glass. When mixed with linseed oil, the ochrey variety often takes fire spontaneously.

Newkirkite of Thomson, found in small four-sided acicular crystals on a fibrous red hæmatite from Neukirchen in Alsace, seems a connected mineral, but is still imperfectly known. It has a brilliant black colour; splendent metallic lustre; H. = 3 — 3·5; G. = 3·824; and consists, according to Muir's analysis, of 56·30 binoxide of manganese, 40·35 peroxide of iron, and 6·40 water (= 103·35).

Ochres.

The following substances, chiefly products of decomposition, may be described here as an appendix to the foregoing families of oxidized ores.

366. Cobalt-ochre, *N.*; Earthy cobalt, *Phillips*; Erdkobalt, *Hausmann.*

Amorphous, encrusting, or disseminated. Fracture earthy. H. = 1 —

2; G.= 2 — 2·65. Colour yellowish-grey or brown to liver-brown; streak brown or yellowish-grey and shining. In the closed tube yields water. B.B. emits odour of arsenic, and fuses to a black magnetic slag; with borax forms a smalt-blue glass. According to Rammelsberg, it is a mixture of hydrous arseniate of iron protoxide, cobalt peroxide, lime, and a little antimony. It is a product of decomposed smaltine; and occurs at Camsdorf and Saalfeld in Thuringia, Riechelsdorf in Hessia, Allemont in Dauphiné, and other localities.

367. MOLYBDENA-OCHRE; Molybdänocher, *Karsten;* Oxide of Molybdena, *Phillips.*

Fine earthy and friable; incrusting or disseminated. Opaque, dull; straw, sulphur, or orange-yellow. B.B. on charcoal fuses and smokes; with soda is reduced to a grey metallic powder; with borax acts like molybdic acid. Soluble in hydrochloric acid, the solution being coloured blue by iron. It is essentially $\dot{M}o$, or molybdic acid with 66·6 molybdena and 33·4 oxygen (or, according to the recent investigations of Svanberg and Struve, 65·71 molybdena and 34·29 oxygen). It seems a product of molybdanite, with which it occurs in granite or gneiss, as at Linnas in Smoland, Bispberg in Sweden, Nummedal in Norway, in the Pfälzer Thal in the Tyrol, and on Corybuy near Loch Creran in Scotland.

368. BISMUTH-OCHRE, *Allan;* Wismuthocher, *Werner;* Oxide of Bismuth, *Phillips;* Bismuth oxidé, *Hauy.*

Occurs massive and disseminated, or earthy and pulverulent. Very soft and friable. G. = 4·36 — 4·7. Opaque; dull or glimmering; straw-yellow to light-grey or green. B.B. acts like bismuth peroxide; on charcoal is easily reduced; easily soluble in nitric acid. Chem. com. $\dot{B}i$, or peroxide of bismuth, with 89·87 bismuth and 10·13 oxygen, but sometimes mixed with a little iron, copper, or arsenic. It arises generally from the oxidation of bismuth with which it occurs at Schneeberg and other localities in the Erzgebirge, in Siberia, and St Agnes in Cornwall. In an earthy steatitic mineral from the last locality, Macgregor found 28·8 bismuth oxide, 51·3 carbonic acid, 2·1 iron peroxide, 7·5 alumina, 6·7 silica, and 3·6 water. It seems evidently a mere mixture.

369. ANTIMONY-OCHRE; Antimonial ochre, *Phillips;* Antimoine oxidé, *Hauy;* Spiess-glanzocher, *Hausmann, Mohs.*

Occurs massive, disseminated, and as a pulverulent crust; also in pseudomorphs after antimonite. Fracture uneven and earthy. Soft and friable. G. = 3·7 — 3·8. Opaque; dull or glimmering, with

glistening streak; colour straw, sulphur, or ochre-yellow, yellowish-grey or white. In the closed tube yields water. B.B. is not reduced, but forms a stain on the charcoal. Easily reduced with soda. Chem. com., probably antimonious acid, $\dot{S}\dot{b}$, with water. It occurs with antimonite at Wolfsberg in the Harz, Kremnitz in Hungary, in Saxony, France, Spain, and at Padstow in England.

370. TUNGSTEN-OCHRE; Wolframocher, *Hausmann;* Scheelsaure, *Naumann.*

Occurs earthy and disseminated, or forms pulverulent incrustations. Soft. Opaque, dull, yellow or yellowish-green. B.B. on charcoal in the reducing flame, becomes first blackish-blue and then black; with fluxes acts like tungstic acid. Wholly soluble in caustic ammonia. Chem. com. tungstic acid $\dot{W}$, with 80 tungsten and 20 oxygen. It is found with wolfram in a quartz vein at Huntington in North America.

371. URANIUM-OCHRE; Uran ochre, *Phillips, Werner;* Urane oxidé terreux, *Hauy*

Occurs massive, disseminated or incrusting. Fine earthy or fibrous. Sectile, soft, and friable. Opaque, dull, or glimmering. Straw, sulphur, or orange-yellow. In the closed tube yields water, and becomes red. B.B. in the reducing flame becomes green, but does not fuse; with salt of phosphorus forms in the oxidating flame a yellow, in the reducing flame a fine green glass. Easily soluble in acids. Chem. com. probably $\dot{U}$, with water in uncertain amount. It occurs with pechurane at Joachimsthal in Bohemia, Johann-Georgenstadt in Saxony, and at St Symphorien in France in granite.

372. MINIUM (Native), *Phillips;* Mennige, *Hausmann;* Plomb oxidé rouge, *Hauy.*

Occurs massive, disseminated, or investing; also as a pseudomorph after cerussite and galena. Fracture even or flat, conchoidal and earthy; H. = 2 — 3; G. = 4·6. Opaque, dull or weak resinous inclining to pearly. Colour aurora-red, streak orange-yellow. B.B. heated gently it becomes darker, and on ignition yellow, and fuses easily, being reduced to lead on charcoal. In hydrochloric acid loses its colour, and is changed into chloride of lead; soluble in nitric acid, which leaves the brown hyperoxide. Chem. com. probably that of the artificial minium, or $\dot{P}b + 2\,\dot{P}b$, with 90·7 lead and 9·3 oxygen. Minium is often a produce of the decomposition of other lead ores, sometimes, as at the Schlangenberg in Siberia, from the action of fire. It also occurs at Badenweiler, Bleialf in the Eifel, in Anglesea

in veins in clay-slate, and at Grassington moor and Weirdale in Yorkshire. It is a not uncommon product of metallurgic processes, and many so-called native miniums have been formed in this manner.

373. LEAD-OCHRE; Plumbic ochre, *Dana;* Bleiglatte, *Hausmann;* Giatte, *Naumann.*

Massive; G. = 8·0. Opaque, dull, sulphur or lemon-yellow. In other respects similar to the artificial yellow oxide of lead, or $\dot{P}b$ with 92·8 lead, and 7·2 oxygen. According to von Geralt, it occurs among the volcanic products of Popocatepetl in Mexico. John examined another supposed natural lead-ochre from Eschweiler, which contained 93·27 lead protoxide, 3·85 carbonic acid, 0·48 peroxide of iron and lime, 2·40 silica, with iron peroxide and a trace of copper protoxide (= 99·90).

374. CHROME-OCHRE, *Hausmann;* Oxide of Chrome, *Phillips.*

Occurs in loose earthy masses, disseminated or investing. Fracture earthy. Opaque or translucent on the edges; dull; colour grass-green to siskin or yellowish-green. B.B. infusible; with borax forms an emerald-green glass. Soluble to a green fluid in solution of potash. Chem. com. perhaps $\ddot{C}r$ or oxide of chrome, with 68·65 chromium, and 31·35 oxygen, but rarely pure. It occurs in fissures of chromite on Unst in Zetland. In general the chrome oxide is so mixed with the rock as only to be separable by chemical means, when it is sometimes named *chrome-stone.* In such a mixture from Creuzat in France, Drappiez found 13 per cent. chrome oxide, with 52 silica, 27 alumina, 4·5 lime, and 2 iron peroxide; Zellner, in a variety from Waldenburg in Silesia, only 2 per cent. chrome oxide; and Hisinger, in a clay from Mortenberg in Sweden, 10 per cent. protoxide of chrome. The chrome-ochre from the porphyry of Halle is a product of its decomposition, and is on the whole merely a kaolin, with part of the alumina replaced by chrome oxide. Wolff found, on a mean of two analyses, 46·11 silica, 30·53 alumina, 3·15 iron peroxide, 4·28 chrome oxide, 3·44 potash, 0·46 soda, and 12·52 water (= 100·49). It has G. = 2·701, and is scarcely affected by hydrochloric, but decomposed by sulphuric acid.

Wolchonskoite, an emerald or blackish-green massive mineral from Okhansk in Perm, is a similar mixture, with more chrome oxide; Berthier having found 34 per cent., Kersten 17·93, and Ilimoff 31·24 per cent. of chrome oxide.

375. TELLURITE; Tellurium-ochre, *Petz.*

Occurs in very small spherical masses with a radiated fibrous

structure. Colour yellowish or greyish-white. B.B. on charcoal and in the open tube acts like tellnric acid Te. It occurs very rarely at Facebay and Zalathna in Siebenbürg.

IV. Family.—The Red Copper Ores.

376. Cuprite, *Haidinger;* Red Copper Ore, *Allan;* Red oxide of copper, Oxydulated Copper, *Phillips;* Rothkupfererz, *Werner;* Cuivre oxidulé, *Hauy;* Octahedral Copper Ore, *Mohs.*

Tesseral; the most common forms are O, ∞O, and ∞O∞; faces of 2O, 2O2, and other forms, more rarely appear. The crystals are seldom imbedded, usually attached and combined in druses. It also occurs in granular or compact aggregates. Cleavage, octahedral rather perfect. Brittle. H. = 3·5 — 4; G. = 5·7 — 6. Translucent or opaque; lustre metallic-adamantine; colour cochineal and other shades of red, sometimes with a lead-grey tarnish; occasionally crimson in transmitted light. Streak brownish-red and shining. B.B. on charcoal becomes black, fuses quietly, and forms a grain of copper. In the forceps colours the flame pale-green, and, moistened with hydrochloric acid, a fine blue. Soluble in hydrochloric or nitric acid, and in ammonia. Chem. com. $\dot{C}u$, with 88·9 copper and 11·1 oxygen. Klaproth, in a foliated variety from Turjinsk, Siberia, found 91 copper and 9 oxygen, probably by an error; Chevenix, in that from Cornwall, 88·5 copper and 11·5 oxygen.

Cuprite occurs in beds or veins, especially in granite, the crystalline schist and transition rocks, along with other ores of copper, and galena, blende, and pyrites. It occurs in great abundance, and in fine crystals, in Siberia, the Bannat, and Cornwall in the Wheal Gorland, Wheal Muttrel, Carvath, and United mines. Fine crystals also occur at Chessy near Lyons, Linares in Spain, in Cuba, and in several places both in North and South America. It has also been found encrusting some slags ejected by Vesuvius.

377. Chalcotrichite, *Glocker;* Capillary Red oxide of Copper, *Phillips;* Kupferblüthe, *Hausmann.*

Rhombohedric, R 99° 15′; usual form ∞R . 0R. It occurs in fine capillary crystals, grouped in bundles or reticulated. Cleavage, rhombohedric along R perfect. G. = 5·8. Colour cochineal and crimson red. In chemical and other characters agrees with cuprite. Occurs at Rheinbreitenbach, Moldawa, and at Wheal Gorland, Carharrack, and St Day in Cornwall.

Suckow first pointed out the distinct crystallization of this mineral. Kersten found selenium in a specimen from Rheinbreitenbach; but v. Kobell and others have sought for this substance without success. It seems, therefore, like cuprite, the simple suboxide of copper, which is consequently dimorphous.

The *Tile ore* (*Ziegelerz*, Werner, *Kupferbraun*, Hausmann) is reddish-brown, or brick-red and earthy. It consists of suboxide of copper, mixed with much peroxide of iron and other substances, and is found in the Bannat, Thuringia, Cornwall, and on Llanymynech hill in Shropshire.

378. TENORITE, *Semmola.*

Hexagonal, forming thin tabular crystals from ½ to 5 lines in diameter attached by the edge. It is also found fine scaly or earthy. In thin foliæ, translucent and brown; lustre metallic; colour dark steel-grey or black. It is a natural protoxide of copper, $\dot{C}u$ = 79·83 copper and 20·17 oxygen; and occurs in fissures of lava in one of the smaller craters on Vesuvius.

379. ZINCITE, *Haidinger;* Zinc oxidé ferrifere, *Hauy;* Red Oxide of Zinc, *Phillips;* Red Zinc, *Jameson;* Zinkoxyd, *Hausmann;* Prismatic Zinc Ore, *Mohs.*

Hexagonal; but only found disseminated in crystalline, granular, or foliated aggregates. Cleavage, basal and prismatic along ∞P both very perfect; also a laminar structure parallel to the basis. H. = 4 — 4·5; G. = 5·4 — 5·5. Translucent on the edges; lustre adamantine; colour blood or hyacinth-red; streak orange-yellow. B.B. infusible, but phosphoresces, and on charcoal, especially with soda, forms a coating of zinc. With borax and salt of phosphorus shows reaction for manganese. Chem. com. probably $\dot{Z}n$, with 80·26 zinc and 19·74 oxygen. Bruce found 8 per cent. peroxide of manganese and iron; Berthier 12 per cent. protoperoxide of manganese; Whitney, in one variety, 94·45 zinc oxide, with trace of manganese, and 4·49 of mixture of franklinite; in another, 96·19 zinc oxide, 3·70 manganese peroxide, and 0·10 magnetic iron; Hayes, 93·5 zinc oxide, 5·5 manganese protoxide, and 0·4 peroxide of iron.

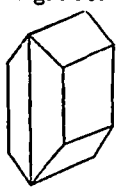
It occurs with franklinite and calc-spar at Franklin and Sterling in New Jersey, and is a good ore of zinc. Minute hexagonal prisms, terminated by pyramids, of this mineral, have been observed in the zinc furnaces near Liege, and in many iron furnaces, as those of Königshütte in Silesia.

V. Family.—The White Antimony Ores.

380. Valentinite, *Haidinger;* White Antimony, *Jameson;* Oxide of Antimony, *Phillips;* Weiss-Spiessglaserz, *Werner;* Antimonblüthe, *v. Leonhard;* Prismatic Antimony-Baryte, *Mohs.*

Rhombic; ∞P 137°, P̆∞ 70½°. The crystals usually of ∞P̆∞ . ∞P . P̆∞ (fig. 236), are broad prismatic, or long tabular, attached singly or combined in fan-shaped, diverging, radiating, or cellular groups. It also occurs massive and disseminated in granular, columnar, or foliated aggregates. Cleavage prismatic, along ∞P very perfect, brachydiagonal imperfect. Sectile and very easily frangible; H. = 2·5 — 3; G. = 5·5 — 5·6. Translucent or semitransparent; lustre adamantine or pearly on ∞P̆∞; colour yellowish and greyish-white, yellowish-brown, ash-grey, blackish-grey, and rarely peach-blossom-red. Streak white. B.B. becomes yellow, and fuses very readily (in the flame of a candle) to a white mass. In the closed tube wholly sublimes. On charcoal forms a thick white coating, and in the reducing flame gives metallic antimony. Easily soluble in hydrochloric acid; the solution yields with water a white precipitate. Chem. com. $\dot{S}\ddot{b}$ with 84·32 antimony and 15·68 oxygen.

Fig. 236.



Occurs in veins in primary rocks with other antimony ores, galena, and blende, at Przibram in Bohemia, and at Braunsdorf in Saxony; more rarely at Wolfsberg in the Harz, Horhausen in Nassau, in Baden, Hungary, near Allemont in Dauphiné, and at Nertschinsk in Siberia.

381. Arsenite, *Haidinger;* Oxide of Arsenic, *Phillips;* Arsenikblüthe, *Hausmann;* Arsenic oxide, *Hauy;* Octahedral Arsenic-acid, *Mohs.*

Tesseral, O. It usually occurs in crystalline, or capillary, flaky, or pulverulent incrustations. Cleavage octahedral; H. = 1·5 (3, *Breithaupt*); G. = 3·6 — 3·7. Translucent; lustre vitreous; colourless and white; taste sweetish astringent. Highly poisonous. B.B. in closed tube sublimes in small octahedrons; with charcoal is reduced and volatilizes with strong smell of garlic. Difficultly soluble in water, the solution becomes yellow with sulphuretted hydrogen, and then on adding hydrochloric acid forms a yellow precipitate. Dissolved in hydrochloric acid alone, it forms a grey metallic coating on copper. Chem. com. arsenious acid, or $\ddot{A}\ddot{s}$ with 75·76 arsenic

and 24·24 oxygen. It is often mixed with sulphuret of arsenic, and then has a red or yellow colour.

This mineral is a secondary product arising from the oxidation of arsenic or decomposition of ores containing this metal. It is found chiefly in the upper part of veins, as at Andreasberg in the Harz, Biber in Hanau, Joachimsthal in Bohemia, Kapnik in Siebenburg, Markirch in Alsace, and Gistain in the Pyrenees. It is often formed by sublimation in the furnaces of the Hartz; and, according to Wöhler, is dimorphous. It is used for preparing colours, in the manufacture of glass, and in medicine.

V. ORDER.—NATIVE METALS.*

382. PLATINA; Native Platina, *Phillips;* Gediegen Platin, *Werner;* Platine natif, *Hauy;* Polyxene, *Hausmann;* Hexahedral Platina, *Mohs.*

Tesseral. It occurs very rarely in small cubes, commonly in minute, flat, or obtuse-angled grains, with smooth shining surfaces. Sometimes in larger grains and roundish lumps, with an irregular granular structure. Cleavage wanting. Fracture hackly. Malleable and ductile. H.=4—5; G.=17—18 (the Russian = 17·3—17·5, *Osann;* a piece weighing 1088 grains, from South America, 18·947, *Tralles*). Steel-grey inclining to silver-white. Sometimes slightly magnetic. Very difficultly fusible. In nitrochloric acid forms a red coloured solution from which ammonia throws down yellow ammoniafe of platina, which, on ignition, is changed into spongy platina. Chem. com. platina, but generally alloyed with iron, iridium, and other metals. When dissolved in nitrochloric acid it leaves a residuum, sometimes of quartz or other stony minerals, sometimes of chromate of iron, but, when metallic, chiefly osmium-iridium. According to Svanberg, the platina and iron are united in determinate proportions; Nos. 1, 2, 7 being $Fe\ Pt^2$; Nos. 3, 5, 6, $Fe\ Pt^3$; and No. 4, $Fe\ Pt^4$. Analyses, next page.

* The metals form only one family. They are all opaque, and possess metallic lustre. This is also generally true of the following order; and this part of the description has been omitted, as unnecessary repetition.

	Platinum.	Iridium.	Rhodium.	Palladium.	Osmium.	Iron.	Copper.	Mangan.	Osmium iridium.	Total.	
1	78·94	4·97	0·86	0 28	...a	11·04	0·70	...	1·96	98·75	Berzelius.
2	73·58	2·35	1·15	0·30	...a	12·98	5·20	...	2·30b	98·46	Do.
3	96·50	...	1·15	1·10	...a	8 32	0·45	...	1·40	98·92	Do.
4	84·30	1·46	3·46	1·0	1·03	5·31	0·74	...	... c	98·08	Do.
5	86·16	1·09	2·16	0 35	0·97	8 03	0·40	0·10	1·91	101·17	Svanberg.
6	84·34	2·52	3·13	1·66	0·19	7·52	trace	0·31	1 56	101·23	Do.
7	83·07	1·91	0·59	0·26	...	10·79	1·30	...	1·80	99·72	Osann.
8	89·87	0·00	4·44	1·30	...	10·92	2·30	...	0·11	100	Do.
9	55·44	27·79	6·86	0·49	trace	4·14	3·30	...	...	98·02	Svanberg.

(a) Part of the loss is osmium; (b) + 0·60 quartz; (c) + 0·60 quartz and 0·12 lime.

From—(1) Nischne-Tagilsk, not magnetic; (2) Do., magnetic; (3) Goroblagodat near Kuschwinsk, not magnetic, fine scaly; (4) Barbacoas, South America, in large grains; (5) Choco; (6) Pinto probably; (7) Nischne-Tagilsk; (8) Ural platina as manufactured in St Petersburg; (9) Brazil.

Platina was first discovered in South America, and named from its resemblance to silver. It was brought to Europe and described by Ulloa in 1741; and determined as a new metal in 1752 by Scheffer, a Swede. In South America it is found chiefly in the provinces of Choco and Barbacoas, in Antioquia in Columbia; also in Brazil (with the diamond), and St Domingo, chiefly in alluvial deposits. At Santa Rosa in Antioquia, Boussingault says it occurs with gold in veins of quartz and limonite. In 1822 it was discovered in the Ural, and is now found in the diluvial sands of almost all the valleys on its eastern declivity, as at Bogoslowsk, Kuschwinsk, Neviansk, Miask, and on the western declivity at Nischne-Tagilsk, where it seems to have been originally disseminated in serpentine, often with chromate of iron, but sometimes alone. In the quartz veins in the granite at Beresow grains of gold and platina have been observed in the same fragment. It is also known in Borneo, and Humboldt says in Birmah, in the Irawaddy, in the Harz, and in France. Dobreiner has procured it in small amount from the gold sand of the Rhine. Pettenkoser asserts that all the silver of commerce, not directly refined, contains it in more or less abundance, and that it is as widely dispersed as gold.

The largest mass from South America in the royal collection at Madrid weighs 1 lb. 9½ oz. avoirdupois, and measures two inches in diameter. It was obtained from the gold mines of Condoto. Another mass weighs about 12 grains. In the Ural larger pieces have occurred, one weighing about 25 Russian pounds, or 18½ lbs. English avoirdupois. These large masses are generally porous, and of lower specific gravity. Its hardness, infusibility, power of resisting acids, and other remarkable properties, render platina a very important material for various chemical, mathematical, and philosophical instruments.

In Russia it is also used for coin. In 1842 the total produce of the Russian mines was 108 poods 20½ lbs.—or about 4430 lbs. troy; and the total amount from 1823, nearly 65,000 pounds troy.

Breithaupt distinguished some specimens from Tagilsk of low specific gravity (14·66 — 15·79), and darker colour, as a peculiar species, under the name of iron-platina. Wollaston described a variety from Brazil, soluble without residue in aqua regia, and containing only a very small amount of gold.

The *Platin-iridium* of Svanberg (No. 9), in small round grains of silver-white colour, and G. = 16·94, seems also a mere variety.

Pettenkoser finds that if an alloy be formed of one part platina and four lead, the whole lead cannot be again separated by nitric acid, some always remaining undissolved in the platina powder, which seems to impart its power of resisting acids to a portion of the less noble metal.

383. PALLADIUM, *Wollaston;* Octahedral Palladium, *Mohs.* Tesseral; according to Haidinger forming very minute octahedrons. More frequently it occurs in small loose grains or scales, in some of which Wollaston observed a radiating, fibrous texture. Cleavage wanting; malleable; H. = 4·5 — 5; G. = 11·8 — 12·2. Colour light steel-grey or silvery-white. B.B. infusible. In nitric acid forms a brownish-red solution. Chem. com. palladium alloyed with platinum and iridium. According to Wollaston it occurs with platina in the gold sands of Brazil. Zincken has found it with gold near seleniuret of lead in greenstone at Tilkerode in the Harz, forming very small, brilliant, hexagonal tables, with distinct cleavage. Hence G. Rose considers it dimorphous.

Is used for astronomical and other instruments; alloyed with silver, by dentists; and, in combination with copper, is supposed to give more elasticity to steel.

384. OSMIUMIRIDIUM; Alloy of Iridium and Osmium, *Phillips;* Rhombohedric Iridium, *Mohs.*

Hexagonal; P 124°. Very minute tabular crystals formed by 0P . ∞P and 0P . P . ∞P (fig. 237), occur loose; but it is more common in small flat grains. Cleavage, basal rather perfect. Slightly malleable, but soon breaks under the hammer, and may then be beat to powder. Not affected by acids. Two species or varieties are distinguished:

Fig. 237.

(*a*) OSMIRIDIUM, *Hausmann;* Pale Osmium-iridium, *G. Rose.* Colour tin-white; H. = 7; G. = 19·386 — 19·471. B.B. not al-

tered. Fused with nitre, in the closed tube it yields osmium vapours, known by their peculiar, unpleasant smell, and forms a green saline mass, which, boiled in water, leaves blue iridium oxide. Chem. com. Ir Os, or by Berzelius' analysis of a specimen from Katharinenburg in the Ural, 46·77 iridium, 49·34 osmium, 3·15 rhodium, 0·74 iron and trace of palladium.

(*b*) Iridosmium, *Haus.*; Dark Osmium-iridium, *G. Rose.* Colour lead-grey; H. = 7; G. = 21·118 (*G. Rose*). B.B. on charcoal becomes black, with a very strong odour of osmium. In the flame of a spirit-lamp shines brightly and colours it yellowish-red. In one variety Berzelius found 25 iridium and 75 osmium, or Ir Os^3; in another, 20 iridium and 80 osmium, or Ir Os^4.

Both minerals occur in the Ural, the former especially at Kuschwinsk and Newjansk in gold sand, the latter in the platina sand of Nischne-Tagilsk, but rarer. The first also occurs in Brazil, and a mixture of these metals has been met with in Borneo. The *Iridium ore* from South America, either found in loose grains of a steel-grey colour, G. = 19·5, or separated from platina by its insolubility in aqua regia, is probably the same mineral. Thomson found in it 72·9 iridium and 2·6 iron, and considered the loss 24·5 as osmium. This mineral is separated from the Ural gold with much difficulty, and by increasing its hardness may prove prejudicial for some purposes.

385. Iridium; Platiniridium, *Hausmann;* Hexahedral Iridium, *Mohs.*

Tesseral; in very small crystals of the form $\infty O\infty$. O; also in small rounded grains. Cleavage, traces along the faces of the hexahedron. Fracture uneven and hackly. Slightly malleable; H. = 6 — 7; G. = 22·6 — 22·8 (*G. Rose*), or 21·57 — 23·46 (*Breithaupt*). Colour silver-white, inclining to yellow on the surface, and to grey in the interior. B.B. unalterable; insoluble in acids, even the nitro-chloric. Chem. com. iridium with platina, or by Svanberg's analysis, 76·80 iridium, 19·64 platina, 0·89 palladium, and 1·78 copper (= 99·11). The specimen was from Nischne-Tagilsk, where and at Newjansk in the Ural it accompanies platina and iridosmium. In the gold sand of Ava a mixture of 60 per cent. iridium, 20 platina; and the remainder, chiefly iron, was found by Prinsep, but is imperfectly known. Iridium is used in porcelain painting to produce black and grey colours.

386. Gold; Gediegen Gold, *Werner;* Or natif, *Hauy;* Hexahedral Gold, *Mohs.*

Tesseral; O; $\infty O\infty$, ∞O, $3O3$, $\infty O2$, and other forms. The

crystals are small and very small; often with one side contracted, elongated, or otherwise deformed, and hence generally indistinct. They are variously grouped, or form macles united by a face of O. Gold is also common in capillary, wire-like, arborescent, interlacing, or moss-like forms; and in plates and foliæ. Very frequently it is found disseminated, often in particles of microscopic minuteness. Cleavage not perceptible. Fracture hackly; H. = 2·5 — 3; G. = 17·0 — 19·4; but porous masses often much lower. Colour gold-yellow to brass or bronze-yellow. Remarkably ductile and malleable. B.B. rather difficultly fusible. Pure gold, with less than ¼ per cent. silver, is not affected by salt of phosphorus, so that the bead remains clear and transparent; with more silver, the bead becomes obscure or opalescent, and when the quantity is considerable, yellow in the reducing flame. Soluble in aqua regia, often with a precipitate of chloride of silver. The solution is yellow, and colours the skin deep purple-red. Where gold contains above 20 per cent. silver, the latter may be separated by fusing the alloy with lead, when nitric acid dissolves the silver and lead. Chem. com. gold with more or less silver, and also copper and iron, so that perfectly pure gold does not seem to occur. G. Rose, in his numerous analyses, sought for platina, and its associated metals, osmium, iridium, rhodium, and palladium, without success. Analyses.

	Gold.	Silver.	Copper.	Iron.	Total.	
1	98·00	2·00	...	...	100	Boussingault, Bucaramanga.
2	84·50	15·50	...	...	100	Do. Ojas Anchas, S. America.
3	98·96	0·16	0·35	0·05	99·52	G. Rose, Katherinenburg.
4	92·80	7·08	0·02	0·06	99·76	Do. Beresow.
5	88·65	10·64	0·09	0·35	99·73	Do. Newjansk.
6	87·17	12·41	0·05	0·23	99·86	Do. Nischne-Tagilsk.
7	84·89	14·68	0·04	0·13	99·74	Do. Siebenburg.
8	76·41	23·12	0·08	trace	99·61	Do. Titiribi, S. America.
9	60·98	38·38	..	0·33	99·69	Do. Siranowsky in the Altai.
10	95·83	4·34	0·33*a*	...	100	Awdejew, Ural (Rhombic dodecahedron).
11	79·00	20·34	0·66*a*	...	100	Do. Do. (Tetrahedron).
12	70·86	28·30	0·48*a*	....	100	Do. Do. (Octahedron).

(*a*). With iron and loss.

The above analyses, to which many more might be added, show that gold and silver do not unite in any definite proportions, and that the two metals are probably isomorphous. G. Rose has shown that the specific gravity decreases with the amount of silver. Awdejew, however, remarks, that the proportion of the two metals affects the form of the crystals, he having found more gold in the rhombic-dodecahedrons, like No. 10, than in the tetrahedrons, like No. 11, and more in the latter than in the octahedrons, like No. 12. In a specimen from Brazil, Darcet found 5·85 silver, and 0·15 platina, and the

latter metal is perhaps the cause of the steel-grey colour of some varieties. The *ouro poudre*, from the iron mines of Capitania Porpez in Brazil, contains, according to Berzelius, 9·85 palladium and 4·17 silver, with 85·98 gold. Del Rio mentions a combination of gold with 84 — 43 per cent. of rhodium, and a specific gravity, 15·5 — 16·8. The varieties with more than 20 per cent. silver, of a light brass or bronze-yellow colour, are distinguished under the name of *electrum* or *argentiferous gold* by some authors.

Gold is one of the most widely distributed minerals, being found in its original position in nests, beds, or veins, usually of small extent, or disseminated in various rocks, granite, syenite, greenstone, clay-stone porphyry, trachyte, the crystalline slates, and transition strata, often with iron pyrites and quartz; as in Sweden, the Harz, Salzburg, Tyrol, Bohemia, Hungary, Siebenburg; in the Ural and Altai; in the Carolinas, Mexico, Peru, and Brazil. It is more common in the sands or alluvial deposits of the above countries; and in St Domingo, Borneo, Java, Sumatra, China, and Tibet. In these deposits it is often accompanied by platina, iridium, magnetite, nigrine, rutile, anatase, chromite, zircon, and diamond. It is found in the sand of many European rivers, as the Tagus, Rhone, Seine, Danube, Rhine, Lech, Inn, Isar, and Eddar.

In Britain, gold has been found in many of the Cornish stream works, as at Probus, Creed, St Mewan, Carnon, and Crowhill; in many of the mineral lodes near Dolgelly and other parts of North Wales; in Scotland in considerable amount near the Leadhills, and in Glen Coich and other parts of Perthshire; and in Ireland in the Wicklow mountains.

The proportion of gold either in the rocks or sands is very small. In the ores of Rammelsberg, near Goslar in the Harz, it is one part in 5,200,000 ore. The sands of the Rhine contain only one part in eight billions on the average, but are then too poor to be used; those that are washed for gold usually containing from 13 to 15, and rarely 60 to 70 parts in 100,000,000. In Siberia the sands contain 10 times, in Chili 37 times, as much gold as those in the Rhine, and the single particles are from 200 to 400 or even 1000 times larger than in that river, where 17 to 22 only weigh a milligramme, or 1100 to 1400 one grain troy. In the mines at Beresow in the Ural 100 pud ore yields 5·3 solotnik gold on an average, or one part in 72,000.

Chevalier recently estimated the total produce of the world in gold in the beginning of this century at about 66,500 lbs. troy, and now at 130,000 lbs., worth above six millions sterling. Of this America produced 40,000 lbs.; Europe, 3,500 lbs.; Russia, 30,500 lbs.; Africa, 10,700 lbs. and the Sunda islands, 12,600 lbs. troy. The

Russian mines were stated officially to have produced, in 1846, 1722·746 pud, or 72,290 pounds troy of gold, worth L.3,566,000, being a large increase on former years. The produce of the California gold washings, just discovered, must be added to the above estimate, but no satisfactory data regarding the amount have yet been published.

387. SILVER, Gediegen Silber, *Werner*; Argent natif, *Hauy*; Hexahedral silver, *Mohs*.

Tessëral, the cube ∞O∞ being the most common form, then the octahedron O, ∞O, 3O3, ∞O2 and others. The crystals are usually small, and often wedge or segment-shaped from the shortening or elongation of one of the sides. The macles are united by a face of O. It is likewise common in capillary, filiform, moss-like, arborescent, or tooth-like forms, in leaves, plates, or crusts, and also massive or disseminated. Cleavage not observable. Fracture hackly. Malleable and ductile. H. = 2·5 – 3; G. = 10·1 – 11·1. Colour pure silver-white, but often tarnished yellow, red, brown, or black. B.B. easily fusible, and on cooling sometimes crystallizes in octahedrons. Easily soluble in nitric acid; the solution colours the skin black; and with hydrochloric acid gives a voluminous white precipitate, which in the light becomes first bluish, then brown and black. Chem. com. silver, often with gold or other metals, especially platina, which has been found in ores from Spain, France, Germany, and other countries. In a specimen from Kongsberg, Fordyce found 72 silver and 28 gold. In a crystallized specimen from Johann-Georgenstadt, John found 1 per cent. antimony, with traces of copper and arsenic. Native silver from Courcy in Calvados, examined by Berthier, contained 10 per cent. copper. The amount of gold is very various, and it appears to be more often entirely wanting than silver in native gold.

Silver is found in veins, and very rarely in beds, in the crystalline formations, in gneiss, mica, and hornblende slates; in granite, syenite, and porphyry; also in the transition and older secondary rocks, along with various ores, and especially calc spar, fluor spar, quartz, and hornstone. The chief European mines are Andreasberg in the Harz, Freiberg and Johann-Georgenstadt in Saxony (one mass from the latter is said to have weighed 100 cwt.); Joachimsthal and Przibram in Bohemia; Schemnitz in Hungary; and Kongsberg in Norway. In the last, in the year 1666, one piece was found weighing 560 pounds, and another in 1834 weighing 14,448 marks, or about 7½ cwt. The Schlangenberg mines, once the most important in Siberia, are now exhausted. Mexico and Peru still furnish a large proportion of this metal. The auriferous silver, with more than 20 per cent. gold, is

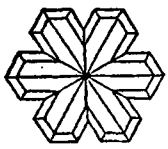
chiefly obtained at Kongsberg. Silver occurs in many localities in Britain, as at St Mewan, St Stephens, Wheal Mexico, and Herland; in Cornwall, and at Alva in Stirlingshire. Most of the so-called silver mines, however, seem to be only veins of argentiferous lead ore.

M. Chevalier has estimated the whole silver produced on the globe in the beginning of this century at 2,400,000 lbs. troy, and recently at 2,080,000 lbs., worth about L.6,888,000. The produce of America is 1,650,000 lbs., of Europe 352,000 lbs., and of Russia 55,500 lbs. troy. In the beginning of the century 36 lbs. silver were produced for one pound of gold, at present only 16 lbs. The whole worth of the precious metals derived from America since its discovery has been estimated at 1,465 million pounds sterling,—an immense sum, but exceeded by the produce of the coal mines and connected manufactures of Britain in four or five years.

388. ANTIMONY-SILVER; Antimonial silver, *Phillips;* Spiessglassilber, *Werner;* Prismatic Antimony, *Mohs.*

Rhombic; P with polar edges 132° 42′ and 92°, ∞P 120° nearly. The crystals usually formed of ∞P . ∞P̆∞ . 0P, or this with P and 2P̆∞ or other forms, are short prismatic or thick tabular, the prisms vertically striated, and their faces often concave. The macles are united by a face of ∞P; and when three crystals are so conjoined, they form six-sided prisms, scarcely to be distinguished from an hexagonal combination. Such compound prisms are often again united, three or six together, in stellar groups (fig. 238). Usually it occurs massive and disseminated, or in granular aggregates. Cleavage, basal and domatic along P̆∞ distinct; prismatic along ∞P imperfect. Rather brittle, and slightly malleable. H. = 3·5; G. = 9·4 — 9·8. Silver-white to tin-white, sometimes with a yellow or blackish tarnish. B.B. in the closed tube gives a sublimate of antimony-oxide, on charcoal fuses easily, fumes, staining the support white, and at length leaves a grain of silver. Soluble in nitric acid, leaving antimony-oxide. Chem. com. $Ag^4 Sb$, with 77 silver and 23 antimony. Analyses.

Fig. 238.



	Silver.	Antimony	Total.	
1	75·25	24·25	99·50	Abich, Andreasberg.
2	78	22	100	Vauquelin, Do.
3	77	23	100	Klaproth, Do. foliated.
4	76	24	100	Do. Wolfach, coarse granular.
5	84	16	100	Do. Do. fine granular.

The last corresponds to $Ag^6 Sb$, but was probably a mixture of

antimony-silver with pure silver. This rather rare mineral is found in the crystalline rocks with various ores, and especially with arsenic and calc-spar. Very fine varieties occur at Andreasberg in the Harz, and formerly at Altwolfach in Baden, and others at Allemont in Dauphiné, Casalla in Spain, and Arqueras in Coquimbo in South America. Where abundant it is a valuable ore of silver.

The *Arsenic-silver* seems a mere mixture of this mineral with arsenic or arsenical pyrites.

389. MERCURY; Native Quicksilver, *Phillips;* Gediegen Quecksilber, *Werner;* Mercure natif, *Hauy;* Fluid Mercury, *Mohs.*

When fluid amorphous, but at —40° congeals, and forms tesseral crystals. G.=13·5—13·6 (13·545 fluid, 15·612 solid, *Biddle*). Bright metallic lustre; colour tin-white. B.B. wholly volatile, or leaves a little silver. Chem. com. mercury, Hg, sometimes with a little silver.

Mercury, though not common, occurs in rocks of all ages, chiefly with cinnabar in veins or fissures. Its best known localities are Idria in Carniolia, and Almaden, and Almadenejos in Spain. In Germany at Wolfstein, Mörsfeld, and Moschel-Landsberg in the coal formation of the Rhine, and in minute quantities near Clausthal in the Harz. It occurs in the tertiary deposits near Lisbon and Montpellier, and it is said in clay near Berwick in Scotland. It is also found at Huancavelica and other parts of Peru, in China, and in the Altai mountains. In 1844 the Spanish mines produced 20,796 cwt. of this metal.

390. AMALGAM; Native amalgam, *Phillips;* Mercure argental, *Hauy;* Dodecahedral Mercury, *Mohs.*

Tesseral; sometimes very beautifully crystallized, especially the rhombic dodecahedron ∞O, variously combined with $2O2$, O, $\infty O\infty$, $3O\frac{3}{2}$, and $\infty O3$. It is also found compact, disseminated, or forming crusts and plates. Cleavage, sometimes in traces along ∞O, but in general only the conchoidal fracture visible. Rather brittle. H. = 3 — 3·5; G. = 13·7 — 14·1. Colour silver-white, and gives the same colour to copper when rubbed upon it. In the closed tube yields mercury and leaves silver. Easily soluble in nitric acid. Chem. com. sometimes $Ag\,Hg^2$, with 35 per cent; sometimes $Ag\,Hg^3$, with 26·5 per cent. silver. Analyses.

	Silver.	Mercury	Total.	
1	25·00	73 30	98·30	Heyer, Moschellandsberg.
2	36·00	64·00	100	Klaproth. Do.
3	27·50	72 50	100	Cordier, Allemont?
4	86·49	13·51	100	Domeyko, Arqueros, Chile.

Amalgam occurs chiefly in the quicksilver mines at Mörsfeld and Moschellandsberg in Rhenish Bavaria, and at Szlana in Hungary; also, it is said, at Salberg in Sweden, Allemont in Dauphiné, and Almaden in Spain. No. 4, the *arquerite* of Domeyko, forms the chief ore in the rich silver mines of Arqueros near Coquimbo. It occurs in small octahedral crystals, and arborescent forms, is ductile and malleable; H. = 2 — 2·5; G. = 10·8. Its chem. com. is $Ag^6 Hg$, and B.B. it acts like amalgam.

391. ANTIMONY; Native A., *Phillips;* Gediegen Spiesglass, *Werner;* Antimon, *Naumann;* Antimoine natif, *Hauy;* Rhombohedral Antimony, *Mohs.*

Rhombohedric, R 117° 15′, but very rarely occurs crystallized, generally massive and disseminated; sometimes in spherical, botryoidal, and reniform aggregates, with a granular texture. Cleavage, basal highly perfect, rhombohedral along R perfect, and along —2R imperfect. Fracture not perceptible. Rather brittle and somewhat sectile. H. = 3 — 3·5; G. = 6·6 — 6·8. Tin-white, with a greyish or yellowish tarnish. B.B. easily fusible, and on cooling crystallizes in rhombohedrons; on charcoal burns with a weak flame, and volatilizes, forming a white deposit. In the closed tube yields a white sublimate. Chem. com. antimony, usually with a small amount of silver, iron, or arsenic. In a specimen from Andreasberg, Klaproth found 98 antimony, 1 silver, and 0·25 iron. This mine is its principal European locality, but it also occurs at Przibram in Bohemia, and formerly at Sala in Sweden, and Allemont in Dauphiné. It is also known in Mexico and Borneo.

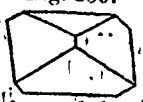
392. ARSENIC-ANTIMONY; Arsenical antimony, *Phillips;* Antimonarsen, *Naumann;* Arsenikspiessglanz, *Mohs.*

Rhombohedric; in spherical or reniform masses, with a curved lamellar structure, and a granular or almost compact texture. H. = 3·5; G. = 6·1 — 6·2. Colour tin-white, approaching to lead-grey, and more or less tarnished with brownish-black. B.B. gives out a strong smell of arsenic. Chem. com. $Sb\,As^3$, according to Rammelsberg's analysis of the variety from Allemont, 37·85 antimony and 62·15 arsenic. But the two elements are isomorphous, and form no definite compound, as Steinmann and others have shown. Its chief locality was formerly Allemont in Dauphiné; also, Przibram in Bohemia, Schladming in Styria, and Andreasberg in the Harz.

393. ARSENIC; Native Ar., *Phillips;* Arsen, *Naumann;* Arsenic natif, *Hauy;* Rhombohedral Arsenic, *Mohs.*

Rhombohedric; R 114° 26′. The forms known are 0R, R, —2R

Fig. 239.



85° 26′ (fig. 239), but seldom distinctly crystallized. It usually occurs in fine granular, almost compact, or rarely columnar aggregates, or botryoidal, reniform, or spherical, with a curved lamellar structure; also massive and disseminated. Cleavage, basal perfect, rhombohedric along R and −2R imperfect. Fracture uneven and fine granular. Brittle. H. = 3·5; G. = 5·7 — 5·8. Whitish lead-grey on the fresh fracture, but in a few hours acquires a greyish-black tarnish. When broken or heated, gives out arsenical odours. B.B. easily fusible, but on charcoal gives off dense white vapours, and may be wholly volatilized without fusing. In the closed tube forms a metallic sublimate. With nitric acid changes into arsenious acid. Chem. com. arsenic, with some antimony, and traces of iron, silver, or gold. In specimens from Joachimsthal, John found 2 — 3 per cent. antimony, with 1 per cent. of iron peroxide and water.

Arsenic occurs chiefly in veins in the crystalline and transition strata, with ores of antimony, silver, and lead; as at Andreasberg in the Harz; Annaberg, Schneeberg, Marienberg, and Freiberg in Saxony; Joachimsthal in Bohemia; Kapnik in Siebenburg; Orawitza in the Bannat; Allemont in Dauphiné; St Marie aux Mines in Alsace; and Kongsberg in Norway. Also at Zmeoff in the Altai; in New Hampshire in North America, and in Chili.

In a damp atmosphere arsenic soon tarnishes, and in a few days is covered with a dark coat of the suboxide. Pulverized and moistened, it undergoes spontaneous combustion. It has also a strong tendency to combine with other metals. At Kongsberg it combines thus with silver, and at Andreasberg with antimony and silver; both compounds being named *Arsenic-silver*. Breithaupt's *Arsenic-glance*, from Palmbaum near Marienberg, contains, according to Kersten, 97 arsenic acid and 3 bismuth, and is probably a similar mixture. It has a columnar structure, with a perfect cleavage in one direction. H. = 2; G. = 5·36 — 5·39. Colour dark lead-grey. It takes fire at the flame of a candle, and burns. Arsenic is used in various pharmaceutical preparations and metallurgic processes, but is usually injurious when mixed with ores. It is almost constantly found in iron ores and iron, and Schafhaütl considers its presence as one cause of the excellence of the Dannemora iron, contrary, however, to the common opinion.

394. TELLURIUM; Gediegen Silvan, *Werner*; Rhombohedral Tellurium, *Mohs*.

Hexagonal; P 115° 12′. It is rarely crystallized, in the form ∞P . 0P : P; usually found massive or disseminated, and fine granular. Cleavage, prismatic along ∞P perfect, basal imperfect;

slightly sectile. H. = 2—2·5; G. = 6·1—6·3. Tin-white. B.B. very easily fusible; burns with a greenish flame and much smoke, which forms a white ring with a reddish margin on charcoal. In the open tube burns with a greenish-blue flame, and forms a white sublimate, which can be fused to clear colourless drops. The vapour has often a smell of raddish from selenium. Soluble in nitric acid with evolution of nitrous vapours; and in concentrated sulphuric acid forms a bluish-red solution. Chem. com. tellurium, with a little gold or iron. Analyses.

	Tellurium.	Gold.	Iron.	Sulphur.	Total.	
1	92·55	0·25	7·20	...	100	Klaproth.
2	97·22	2·78	trace	trace	100	Petz.

Occurs along with quartz, iron pyrites, and gold, at Facebay near Salathna in Siebenburg, where it is melted for the gold it contains. It has also been quoted, but probably erroneously, from Norway and Connecticut.

395. LEAD; Native L., *Phillips;* Blei, *Naumann;* Plomb natif volcanique, *Hauy.*

Tesseral, but not observed crystallized; only capillary, filiform, or branched, and in thin plates or disseminated. Ductile and malleable. H. = 1·5; G. = 11·3—11·4. Colour bluish-grey with a blackish tarnish. B.B. very easily fusible; on charcoal volatilizes and forms a sulphur-yellow coating. Soluble in nitric acid. Chem. com. lead. Found in considerable abundance by Rathke in vesicular cavities of lava on the island of Madeira. The specimens found by Launoy in the deserted mines of Carthagena in Spain are more doubtful. It is also said to occur in galena on the Anglaise river in Ohio. Allan observed it in globules in galena at Alston Moor, but seems doubtful of its genuineness. It is also noticed from the carboniferous limestone near Bristol, and at Kenmare in Ireland.

396. TIN.

This metal has not certainly been found native, though quoted by Romé de l'Isle from Cornwall, and by other authors from France and Hindostan. The fused metal crystallizes in regular octahedrons. Frankenheim obtained it in tesseral forms when reduced at low temperatures; Breithaupt from the Cornwall furnaces in hexagonal prisms; whilst Miller describes that formed by galvanic action as tetragonal.

397. BISMUTH; Native B., *Phillips*; Gediegen Wismuth, *Werner*; Bismuth natif, *Hauy*; Octahedral Bismuth, *Mohs*.

Tesseral; O, ∞O, 4O; the crystals are often mis-shapen, or rendered indistinct by their union in groups. It also occurs arborescent, feathery, or reticulated; rarely filiform or in plates; often massive or disseminated and granular. Cleavage, octahedral perfect. Not malleable. Very sectile. H. = 2·5; G. = 9·6 — 9·8. Colour reddish silver-white, often with a yellow, red, brown, or parti-colour tarnish. B.B. very easily fusible, even in the flame of a candle. On charcoal volatilizes, leaving a citron-yellow coating. Soluble in nitric acid; much water throws down a white precipitate from the solution. Chem. com. bismuth; sometimes with a little arsenic.

Bismuth is found in granite and the crystalline slates; in the transition strata, and in the Kupferschiefer, chiefly with ores of cobalt and of silver. Its most important localities are the Saxon Erzgebirge at Schneeberg, Annaberg, Marienberg, Johann-Georgenstadt, and Altenberg; Joachimsthal in Bohemia; Bieber in Hanau; Friedrichsroda in Thuringia; and Wittichen in the Schwarzwald. Also at Modum in Norway; Fahlun in Sweden; St Columb, Bottallach, and Wheal Sparnon near Redruth in Cornwall; Carrack Fell in Cumberland; and formerly at Alva in Stirlingshire. Lane's mine in Connecticut is its only locality in the United States.

398. COPPER; Native C., *Phillips*; Kupfer, *Naumann*; Cuivre natif, *Hauy*; Octahedral Copper, *Mohs*.

Tesseral; O, ∞O∞, ∞O, ∞O2, alone or combined. The crystals are small, and generally irregular, deformed, and grown together. Macles united by a face of O. Often occurs filiform, moss-like, and arborescent; or in plates and laminæ; also investing, massive, and disseminated; rarely in loose grains or lumps. Cleavage, not perceptible. Fracture hackly. Malleable and ductile; H. = 2·5 — 3; G. = 8·5 — 8·9. Colour copper-red, with yellow or brown tarnish. B.B. rather easily fusible, colouring the flame green. Readily soluble in nitric acid; and in ammonia with the access of air forms a blue solution. Chem. com. copper, rarely with a little iron or other metals.

Copper occurs in beds and veins, or disseminated in granite, serpentine, and the crystalline schists, in the transition and secondary strata. Its chief localities are Cornwall, as at Wheal Unity, Mullion, Camborne, St Just, Poldory, and the Lizard; at Chessy near Lyons, the Bannat and Hungary in Europe. Siberia, China, Japan in Asia; in Canada, the United States, Mexico, Cuba, Brazil, and Chili. Some fine crystals occur with fibrous mesotype in amygdaloidal trap

in Nalsoe, one of the Faroe islands. A large mass found near Lake Superior measured 4½ feet long by 4 feet broad, and weighed from 3000 to 4000 lbs., and another from the same locality 1630 lbs. Native silver adheres to both masses. A rolled mass found at Cachoeira in Bahia, now in the museum at Lisbon, weighed about 2600 lbs. Fused copper in favourable circumstances crystallizes in regular octahedrons. Seebeck states that it also forms rhombohedrons, but according to G. Rose this is not the case. It seems sometimes to be deposited in mines from water containing the sulphate, and especially on pieces of wood.

399. Iron; Native I., *Phillips*; Gediegen Eisen, *Werner*; Fer natif, *Hauy*; Octahedral Iron, *Mohs*.

Tesseral; chiefly the regular octahedron. Cleavage, probably hexahedral or also octahedral, but only in indistinct traces. Fracture hackly. Malleable and ductile; H. = 4·5; G. = 7 — 7·8. Colour steel-grey or iron-black, often with a blackish tarnish. Very magnetic. B.B. infusible, or only in thin plates with a strong heat. Soluble in hydrochloric acid. Two varieties are usually distinguished, telluric and meteoric iron.

(*a*) Telluric iron occurs in small grains and plates, or massive and disseminated. It is almost pure iron, but contains carbon, graphite, or occasionally some other metal, but not nickel. Klaproth analyzed a specimen of native iron from Gross Camsdorf in Thuringia, which contained 92·5 iron, 6 lead, and 1·5 copper. It weighed 12 ounces, and part is now in the museum at Berlin, part at Göttingen, and both Kersten and Hausmann regard it as genuine. It has a foliated structure and crystalline granular texture. Schreiber found native iron in a vein at Oule near Allemont in Dauphiné. At Canaan in Connecticut, a vein of native iron two inches broad was observed in mica-slate. It contained carbon or graphite between the laminæ (91·8 iron and 7·0 carbon, *Shepard*). Another specimen from Penn Yan in New York, found in sandstone, contains a little carbon, but no *nickel* or cobalt. The iron discovered near Burlington in New York seems to be meteoric. Proust found iron in some sulphurets from South America; and Eschwege observed it in thin, very flexible laminæ in an ironstone conglomerate near Itabira do Matto Dentro in Brazil. John states that it is mixed with the platina grains from South America. Very recently M. Molnár affirms, that he has found native iron in the gold sands at Olahpian. These sands consist chiefly of garnet, nigrine, ilmenite, and zircon, and the iron is mixed with grains of platina, the two being often attached. It also contains nickel, hitherto believed to occur only in meteoric iron. These very inte-

resting statements still require confirmation. It is also stated that native iron, with six per cent. silica and a little sulphur, has been found with galena in the veins at Leadhills. G. Rose states that the iron said to occur in the platina sands of the Ural is derived from the tools used in washing the sand. The specimens from Kyrburg and from Sweden, are also thought artificial. Mossier has found volcanic iron in lava at Graveneire in Auvergne, probably a natural product. It has a steel-grey or silver-white colour, foliated texture, and hackly fracture. These instances seem to prove that this metal does occasionally occur native.

(*b*) METEORIC IRON contains nickel, along with cobalt and other metals. It is light steel-grey or silver-white, and occurs rarely crystallized in octahedrons, more commonly in large irregular, often cellular masses, or imbedded in meteoric stones. When polished and etched with acids, it exhibits linear and angular markings, or Widmannstatt's figures as they have been named, from which an impression may be printed on paper. A great number of undoubted meteorites have been described and analyzed. The following are a few analyses of meteoric iron.

	Iron.	Nickl.	Cobalt.	Copper.	Mangan.	Magnesium.	Sulphur.	Chlorine.	Insoluble matter.	Total.	
1	93·70	3·81	0·21	...	...	...	...	...	2·20	100	Berzelius.
2	88·04	10·73	0·46	0·07*a*	0·13	0·05	trace	...	0·48	100	Do.
3	88·23	8·52	0·76	...	trace	0·28	trace	...	2·21	100	Do.
4	89·78	8·89	0·67	...	...	...	...	...	...	99·34	Wehrle.
5	85·61	12·27	0·89	...	...	...	...	...	...	98·77	Do.
6	90·33	8·45	0·67	0·002	...	...	...	...	...	100	Do.
7	66·56	24·71	...	...	3·46	...	4·00	1·48	...	99·59	Jackson.
8	90·24	9·76	...	...	...	...	...	...	...	100	Morren.
9	83·57	12·67	...	...	...	...	...	0·91*c*	...	99·54	Hayes.
10	92·58	5·71	...	traced	...	...	indet.	...	1·40	99·69	Silliman.
11	81·3	11·9	1·0	...	0·2	...	5·1	...	...	100	Stromeyer.

(*a*) With tin + 0·04 carbon; (*b*) with chromium; (*c*) + 2·3 sulphuret of iron; (*d*) with arsenic.

The insoluble matter in the above contains in 100 parts:—

In No.	Iron.	Nickl.	Phosphor.	Silica.	Carbon.	Magnesium.	Total.	
1	65·99	1·60	14·02	2·04	1·42	...	98·48	Berzelius.
2	48·67	18·33	10 47	...	...	9·66	95·13	Do.
3	68·11	17·72	14·17	...	...	...	100·0	Do.
10	44·1	24·5	11·4	10·0	...	...	90·0	Silliman.

The above analyses are of: No. (1) a mass 103 lbs. weight which fell at Bohumilitz in Bohemia in 1829. (2) Mass found in 1748 near Krasnojarsk on the Yenisei, weighing about 1600 lbs., and brought by Pallas to St Petersburgh where a portion, 1279 lbs. Russian, is still preserved. (3) the so-called "verwünschte Burggraf" from Elbogen in

Bohemia, which weighed 191 lbs., and is now in the Vienna Museum. Wehrle found in it nearly the same amount of iron, nickel, and cobalt. (4) Mass of 71 Vienna pounds weight, which fell at Hraschina near Agram in Croatia on 26th May 1751. (5) Mass in the Harlem Museum, found in 1793 on the plain between the Great Fish River and Graf Reynet in the Cape Colony; its original weight was 300 lbs., but now only 171 lbs. (6) Found at Lénarto in Hungary, originally 194 lbs., now 134 lbs., in Pesth Museum. (7) From Clairborne in Alabama. (9) Is a more recent analysis of the same. (8) From Potosi. (10) From Lockport in North America. In the analysis of the portion insoluble in hydrochloric acid, 10·0 was a brown powder insoluble in aqua regia, and probably silica, the loss was considered to be oxygen. (11) Bitburg near Treves, weighed above 3300 lbs.

Other remarkable masses of meteoric iron are, that found by Don Rubin de Celis in Tucuman in South America in 1783, weighing 300 cwts.; that discovered in 1784 on the Riacho de Bendego in Brazil, estimated to measure 32 cubic feet, and to weigh 17,300 lbs.; that on the Red River in Louisiana, weighing above 3000 lbs., and presenting distinct octahedral crystals.

Meteoric stones, though intimately connected with the above, are properly not simple minerals, but rather compound bodies resembling certain greenstone or other rocks. Berzelius divides them into two classes. The first, comprising only those which fell at Stannern in Moravia in 1808, and at Jonzac and Juvenas in Languedoc in 1821, is distinguished by containing no metallic iron, by a structure more distinctly crystalline, and by a less predominance of magnesia in the composition. The second, comprising all other meteorites, contains metallic iron sometimes in dispersed grains, sometimes forming a continuous skeleton. The other portion consists of various minerals, especially olivine, augite, hornblende, labradorite, and albite. Rammelsberg considered a meteoric stone which fell at Chateau-Renard in the Loiret department, on the 12th June 1841, and analyzed by Dufrénoy, at first as composed of nickel-iron, olivine, albite, hornblende, and sulphuret of iron; but afterwards gives its composition as 10·0 nickel-iron and sulphuret of iron, 52·5 olivine, 21·3 augite, and 16·2 labradorite (= 100). The meteoric stones from Blansko in Moravia (fell 1833), and from Chantonnay in La Vendée (fell 1812), analyzed by Berzelius, consist in the non-metallic part of olivine, forming about half the earthy matter, and of oligoclase, and augite, in the proportion of one to three. If, however, the felspar is considered as labradorite then the remainder is hornblende. Another, which fell near Nordhausen on the 16th September 1843, Rammelsberg considers composed of 22·90 nickel-iron, 5·62 sulphuret of iron

(Fe S), 1·04 chrome-iron, 38·01 olivine, 12·73 labradorite, 19·76 augite (=100). Small amounts of phosphorus, tin, and copper were also contained in it, or fourteen different substances in all. Further particulars regarding the composition of these very complex bodies (Berzelius found in them one-third of the known elements) is contained in Rammelsberg and the works he refers to. Opinions are much divided in reference to their origin; some persons consider them as thrown from volcanos on the moon; others, as formed in the atmosphere; and others, as cosmical bodies circulating in free space, and occasionally attracted to the earth. The most important collections are in the Mineral Cabinet at Vienna, which in 1843 contained specimens from 94 localities; and in the museum at Berlin, which in 1842 possessed genuine meteorites from 78 localities. The British Museum also contains some very interesting specimens.

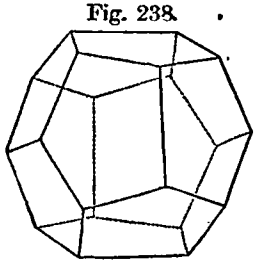
VI. ORDER.—SULPHURETTED METALS.

I. Family.—Pyrites.

400. Pyrite, *Haidinger;* Iron Pyrites, *Phillips;* Schwefelkies, Zellkies, *Werner;* Eisenkies, *v. Leonhard;* Fer sulfuré, *Hauy;* Hexahedral Iron Pyrites, *Mohs.*

Tesseral, and dodecahedral-semitesseral. The cube $\infty O\infty$ is by far the most common form, then O, $\frac{\infty O 2}{2}$ (fig. 238), also $\left[\frac{3O\frac{3}{2}}{2}\right]$, $\left[\frac{4O2}{2}\right]$ and others. The combinations are very numerous (fig. 239), and macles are also frequent (fig. 240), being very characteristic. The crystals often occur imbedded singly, also united in druses and various groups, or in spheroidal, reniform, botryoidal, and other aggregates. Most frequently it is massive and disseminated. Cleavage, hexahedral or octahedral, but both often very imperfect, or scarcely perceptible. Fracture conchoidal or uneven. Brittle; H. = 6 — 6·5; G. = 4·9 — 5·1. Colour a peculiar bronze-yellow,

Fig. 238.



sometimes inclining to gold-yellow, at other times with a brown or

Fig. 239.

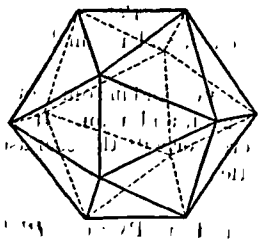
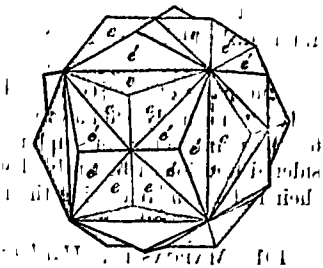


Fig. 240.



rarely variegated tarnish. Streak brownish-black. When broken, emits a smell of sulphur. Yields sulphur in the closed tube. B.B. on charcoal burns with a bluish flame, and a strong smell of sulphur. In the reducing flame fuses to a blackish magnetic bead. Soluble in nitric acid with deposition of sulphur; scarcely affected by hydrochloric acid. Chem. com. FeS_2 with 46·7 iron, and 53·3 sulphur. Hatchett found 47·3 iron, and 52·7 sulphur; Berzelius, 46·08 iron, and 53·92 sulphur. It very often contains gold, silver, or silicium, the gold occasionally in visible grains, at other times so minute as possibly to be a chemical compound.

Pyrite seems to be produced either by igneous action as in volcanos and certain artificial processes; or more commonly from aqueous solution, as in mineral waters, sea water, and moors, especially under the influence of organic matter. It is also very liable to decomposition. Sometimes the sulphur separates, and the iron is changed into the hydrated peroxide; a process that occasionally takes place even in the interior of rocks, probably from the access of water, when the sulphur escapes as sulphuretted hydrogen. At other times it is converted into sulphate of iron and free sulphuric acid, probably from the influence of moist air. This change is more rapid than the former, but is less frequently seen in this species, being more common in the following or marcasite.

Pyrite is one of the most common minerals in rocks of all ages and classes. The following are a few localities remarkable for fine varieties: Elba, pentagonal dodecahedrons three or four inches in diameter; Cornwall, cubes of gigantic dimensions, and other forms; Persberg in Sweden, large, very perfect octahedrons; Traversella in Piedmont, well defined, brilliant crystals. Peru, Freiberg, Schemnitz, Dillenburg, Kongsberg, Arendal, Fahlun, Beresow, Alston Moor, and Derbyshire, also furnish interesting specimens. Fine varieties

occur in the clay at Gross-almerode in Hessia, in the Keuper marls near Rinteln on the Weser, in the chalk at Lewis and Dover, and in the lava of Vesuvius. The auriferous pyrites or Goldkies is found abundantly at Beresow in Siberia, at Marmato in Popayan, in several places in Mexico, at Aedelfors in Sweden, and in small amount in some parts of the Scottish Highlands.

It was formerly used as an ornamental stone; and in some countries for the manufacture of sulphur, sulphuric acid, and alum. It is considered injurious when mixed with iron ores, or with the coal used in their reduction, rendering the metal brittle.

401. MARCASITE, *Haidinger;* White Iron Pyrites, *Phillips;* Strahlkies, Kamkies, Leberkies, *Werner;* Wasserkies, *Hausmann;* Fer sulfuré blanc, *Hauy;* Prismatic Iron Pyrites, *Mohs.*

Rhombic; ∞P 106° 36′, $\frac{1}{3}P\infty$ 136° 40′, $P\infty$ 98° 13′, $\bar{P}\infty$ 64° 30′. The combinations are very various, and besides the above forms show also P and 0P. The crystals like fig. 197 p. 359, and fig. 165, pl 295, appear either tabular, or thin prismatic, or pyramidal. Macles are frequent, sometimes united by a face of ∞P, at others by a face of $\bar{P}\infty$. It also forms cockscomb-like groups or spherical, botryoidal, reniform, and stalactitic aggregates, with a radiated columnar, fibrous, or compact texture. It is common in pseudomorphs, or massive and disseminated. Cleavage, prismatic along ∞P indistinct, along $\bar{P}\infty$ traces. Fracture uneven. Brittle; H. = 6 — 6·5; G. = 4·65 — 4·9. Colour pale, or greyish, bronze-yellow, sometimes almost greenish-grey. Streak dark greenish-grey, or brownish-black. B.B. and with acids acts like pyrite. Chem. com. also identical. Hatchett found 46·4 iron and 53·6 sulphur in one, and 45·66 iron with 54·34 sulphur in another variety. Berzelius, 45·07 iron, 53·35 sulphur, 0·70 manganese, and 0·80 silica (= 99·92).

This mineral is still more liable to decomposition than pyrite, though in the same manner, and most frequently changes to sulphate of iron. In both minerals this has been ascribed to a mixture of Fe; but the above analyses all show a surplus of sulphur, which, though small, would rather indicate a mixture of free sulphur as the cause. It, however, has been observed in pure sulphuret of iron, and seems rather to depend on some peculiarity in the state of aggregation.

Marcasite agrees in its mode of formation and occurrence with pyrite, though rather less abundant and in smaller masses, and more common in veins than in beds. The following varieties are occasionally distinguished. *Radiated pyrites* or *Strahlkies*, in radiated masses of various external forms, common in the Harz, Tyrol, Der-

byshire, and other places; *Spear pyrites* or *Speerkies*, a variety of macle found very fine at Littmitz, Altsattel, Teplitz, and Przibram in Bohemia, Schemnitz in Hungary, and Freiberg in Saxony; *Hepatic pyrites*, or *Leberkies*, named from its liver-brown colour, is generally a pseudomorphous or decomposing variety, common in the Harz, Saxony, Sweden, Derbyshire, and Cornwall; *Cockscomb pyrites* or *Kammkies*, compound, comb-like crystals, often of greenish colour, or with a brown tarnish, very common in Derbyshire, with galena and fluor-spar; also at Zellerfeld and Andreasberg in the Harz.

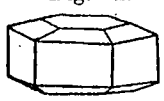
Breithaupt and Glocker distinguish a species under the names of *Weicheisenkies* B. or *Wasserkies* G., which resembles hepatic pyrites, but contains water in chemical union. Its H. = 3 — 4; and G. = 3·33 — 3·50. It occurs in various parts of Moravia and Upper Silesia.

Breithaupt's *Kyrosite* from the Briccius mine near Annaberg is only a variety with part of the iron replaced by copper, and of the sulphur by arsenic, as in Scheidhauer's analysis, 45·60 iron, 53·05 sulphur, 1·41 copper, and 0·93 arsenic (= 100 99). A variety of the *Weisskupfererz* of Werner from Chili contains, according to Plattner, 12·9 per cent. copper, along with iron and sulphur, but no arsenic. It occurs massive, of a whitish bronze-yellow colour, and may be ranged here, at least till better known.

402. PYRRHOTINE, *Breithaupt;* Magnetic Iron Pyrites, *Phillips;* Magnetkies, *Werner;* Fer sulphuré magnetique, *Hauy*; Rhombohedral Iron Pyrites, *Mohs.*

Hexagonal; P 127°. The crystals usually of 0P . ∞P, or this with P (fig. 241) are tabular or short prismatic, but rare. It commonly occurs massive and disseminated, in lamellar, granular, or compact aggregates. Cleavage, basal perfect, prismatic along ∞P imperfect; brittle. H. = 3·5 — 4·5; G. = 4·4 — 4·7. Colour between bronze-yellow and copper-red, with a pinchbeck-brown tarnish; streak greyish-black; more or less magnetic. It remains unaltered in the closed tube, but in the open tube yields sulphurous fumes, but no sublimation. B.B. on charcoal in the reducing flame fuses to a black strongly-magnetic globule. Soluble in hydrochloric acid, evolving sulphuretted hydrogen, and depositing sulphur. Analyses, next page.

Fig. 241.



The composition of this mineral is still rather uncertain. It was generally considered to be Fe, with 63·65 iron and 36·35 sulphur, corresponding nearly to Hatchett's analysis. Stromeyer's experiments, however, gave a different result. G. Rose has shown,—that

	Iron.	Sulphur.	Nickl.	Copper.	Total.	
1	63·5	36·5	...	...	100	Hatchett, Cornwall.
2	59·85	40·15	...	...	100	Stromeyer, Treseburg, Harz.
3	56·37	43·63	...	...	100	Do. Bareges.
4	60·52	38·78	...	...*a*	100·12	H. Rose, Bodenmais.
5	59·64	40·43	...	...	100·07	Plattner, Conghonas, Brazil.
6	59·72	40·22	...	...	99·94	Do. Fahlun.
7	60·59	39·41	..	...	100	Schaffgotsch, Bodenmais (m. of 2).
8	61	39	...	...	100	Berthier, Sitten in Valais.
9	56·03	40·46	2·60	0·40	99·69	Scheerer, Modum, Norway.
10	57·64	38·09	3·05	0·45*b*	100	Berzelius, Klafva, Småland, G. =4·674.

(*a*) + 0·82 silica; (*b*) + 0·09 cobalt, 0·22 manganese; 0·46 garnet-powder.

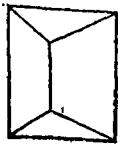
it always contains an excess of sulphur above the simple sulphuret, which is not a mere mixture;—that it is always magnetic, which is not true of the simple sulphuret;—and that its specific gravity is always lower than that of the sesquisulphuret, which should not be the case if it were merely a lower sulphuret. He, therefore, adopts the formula $5\,\dot{F}e + \dot{F}e'''$, with 60·44 iron and 39·56 sulphur. Count Schaffgotsch gives the same formula for Nos. 2, 5, 6 of the above analyses, but says there are two other compounds differing in hardness and specific gravity, and corresponding to certain copper ores. The one is $\dot{F}e + \dot{F}e'''$, with 43·3 sulphur, like No. 3; the other $9\,\dot{F}e + \dot{F}e'''$, with 38·4 sulphur, like Nos. 4 and 7. Naumann takes the same composition with G. Rose, but states it as $Fe^7 S^8$, or $6\,\dot{F}e + Fe''$.

It occurs chiefly in the igneous and crystalline or older stratified rocks in veins with various ores. The above are some of its chief localities to which may be added Kongsberg in Norway, Andreasberg in the Harz, Moel Elion and Llanrwst in Caernarvonshire, Appin in Argyleshire, and the lavas of Vesuvius. It is also found in some meteoric stones in which, it is said, but inaccurately, to be not magnetic.

403. LEUCOPYRITE, *Dana;* Arsenical Pyrites, *Phillips;* Arsenikalkies, *Karsten;* Lölingite, *Haidinger;* Axotomous Arsenic Pyrites, *Mohs.*

Rhombic; ∞P 122° 26′, $\breve{P}\infty$ 51° 20′, $\breve{P}\infty$ 86° 10′. The usual combination is $\infty P \,.\, \breve{P}\infty$ (fig. 242). It generally occurs massive or disseminated, with a granular or columnar structure. Cleavage, basal rather perfect, brachydomatic along $\breve{P}\infty$ imperfect. Fracture uneven. Brittle. H. = 5 — 5·5; G. = 7·1 — 7·4 (6·9 — 7·1, *Breithaupt*). Colour silver-white to steel-grey, with a darker tarnish. Streak greyish black. In the

Fig. 242.



closed tube it gives a sublimation of metallic arsenic. B.B. on charcoal emits a strong smell of arsenic, and fuses to a black magnetic globule, which colours borax glass bottle green. Chem. com. Fe As, with 26·5 iron and 73·5 arsenic, or, according to Scheerer, $Fe^4 As^3$ = 32·5 iron and 67·5 arsenic, but it always contains sulphur, and sometimes nickel and cobalt. Analyses.

	Iron.	Nickel.	Cobalt.	Arsenic.	Sulphur.	Serpentine.	Total.	
1	32·35	...	...	65·88	1·77	...	100·00	Karsten, Reichenstein.
2	30·24	...	...	63·14	1·63	3·55	98·56	Meyer, Do.
3	28·06	...	...	65·99	1·94	2·17	98·16	Hoffmann, Do.
4	13·49	13·37	5·10	60·41	5·20	...	97·57	Do. Schladming.
5	27·39	...	...	70·09	1·33	...	98·81	Scheerer, Fossum.
6	28·14	...	...	70·22	1·28	...	99·64	Do. Do.

This mineral occurs in serpentine at Reichenstein in Silesia; in beds with copper nickel, at Schladming in Styria; with sparry iron at Löling near Hüttenberg in Carinthia; and in veins in clay-slate with various ores at Andreasberg in the Harz. The variety (Nos. 5, 6) from Fossum in Norway, with G. = 7·09 (7·223, *Breit.*), agrees with the first formula, and is considered by Scheerer a distinct species. This mineral is used at Reichenstein for the manufacture of arsenious acid, and a small amount of gold was formerly extracted from it.

404. MISPICKEL; Diprismatic Arsenical Iron, *Phillips*; Arschikkies, *Werner*; Fer arsenical, *Haüy*; Prismatic Arsenic-Pyrites, *Mohs*.

Rhombic, ∞P 111° 53′, ½P∞ 145° 26′, P∞ 80° 8′, P∞ 59° 22′. The most common combinations are ∞P . ½P∞, and this with P∞. The macles are of two kinds. The crystals are generally short prismatic or tabular, imbedded singly or attached and combined in druses. It is also found massive, granular, or columnar, and disseminated. Cleavage, prismatic along ∞P rather distinct. Fracture uneven. Brittle. H. = 5·5—6; G. = 6—6·2. Colour silver-white or almost steel-grey, with a greyish or yellowish tarnish; streak black. In the closed tube yields first a red then a brown sublimate of sulphuret of arsenic, and then metallic arsenic. B.B. on charcoal fuses to a black magnetic globule, which acts like pyrrhotine, and sometimes shows traces of cobalt, colouring borax glass blue. It is soluble in nitric or nitro-chloric acids, with a residue of sulphur and arsenious acid. Chem. com. $Fe S^2 + Fe As$, with 19·9 sulphur,

46·6 arsenic, and 33·5 iron, but some varieties contain silver or gold, in others part of the iron is replaced by cobalt. Analyses,

	Iron.	Arsenic.	Sulphur.	Cobalt.	Total.	
1	36·04	42·88	21·08	...	100	Stromeyer, Freiberg.
2	35·62	43·73	20·65	...	100	Karsten, Do.
3	33·98	45·74	19·60	...	99·32	Thomson, Sweden.
4	34·46	45·46	20·07	...	99·99	Plattner (the Plinian).
5	26·54	47·55	17·57	8·31	99·97	Scheerer, Skutterud.
6	26·36	46·76	17·34	9·01	100·47	Do. Do.
7	26·97	46·01	16·06	8·38	99·42	Do. Do.
8	30·91	47·45	17·48	3·75	100·59	Wöhler, Do.
9	32·94	41·44	17·84	6·45 *a*	99·68	Hayes (the Danaite).
10	36·44	55·00	8·34	... *b*	99·79	Jordan, Andreasberg.

(*a*) + 1·01 impurities; (*b*) + 0·011 silver.

Mispickel occurs chiefly in igneous rocks, or the crystalline and transition strata. It is common in Saxony in veins at Freiberg, in beds at Breitenbrunn and Raschau; in Bohemia in the tin mines of Joachimsthal, Zinnwald, and Schlackenwald; in Silesia, Hungary, in the veins of silver ores at Andreasberg, and with copper ores at Rammelsberg in the Harz; in Sweden at Sala, Nora, and Tunaberg; in various parts of North America, and in Cornwall in Wheal Maydlin, Unanimity, and other tin mines. The cobalt-mispickel, Nos. 5–8, is chiefly from Skutterud near Modum in Norway. The *Danaite*, No. 9, from Francouia in New Hampshire, North America, seems the same mineral. The *Plinian* of Breithaupt, No. 4, with G. = 6·272 —6·467, agrees in composition, but the crystals are monoclinohedric, so that this compound must be dimorphous. It occurs at St Gotthardt, Ehrenfriedersdorf, and Zinnwald. The *Weisserz* of Werner were the varieties containing silver, like No. 10, which, however, differs in composition. Mispickel is used as an ore of arsenic, and occasionally of silver.

405. COBALTINE, *Beudant*; Bright white Cobalt, *Phillips*; Glanz cobalt, *Werner*; Cobalt gris, *Hauy*; Hexahedral Cobalt Pyrites, *Mohs*.

Tesseral and dodecahedral-semitesseral. The usual forms and combinations resemble those of pyrite above. The crystals are chiefly imbedded, and it also occurs massive, granular, or disseminated. Cleavage, hexahedral perfect. Brittle. H. = 5·5. G. = 6·0 — 6·1 (— 6·35 *Hausmann*). Colour silver-white, inclining to red; often with a greyish or yellowish tarnish. Streak greyish-black; lustre brilliant. In the open tube, in a strong heat, yields arsenious acid and sulphurous fumes. B.B. on charcoal fuses with strong smell of arsenic to a grey, weak magnetic globule. After roasting shows reaction for

cobalt with borax. Soluble in warm nitric acid, depositing arsenious acid. Chem. com. $Co S^2 + Co As$, with 35·5 cobalt partly replaced by iron, 45·2 arsenic, and 19·3 sulphur. Analyses.

	Cobalt.	Iron.	Arsenic.	Sulphur.	Total.	
1	33·10	3·23	43·46	20·08	99·87	Stromeyer, Skutterud.
2	29·77	6·38	44·75	19·10	100	Schnabel, Siegen.
3	30·37	5·75	44·13	19·75	100	Hubert, Orawitza.
4	32·62	4·56	43·63	19·78	99·99	Patera, Do.

Found chiefly in the crystalline slates in beds, especially at Skutterud in Norway, Tunaberg in Sweden, in large resplendent crystals; Querbach in Silesia, and St Just in Cornwall. The variety from Orawitza is mixed mechanically with native bismuth (18·40 per cent. in No, 3), and traces of gold. The mixture had G. = 7·4 — 7·5.

406. SMALTINE, *Beudant;* Tin-white Cobalt, *Phillips;* Grey Cobalt, *Allan*; Speiskobalt, *Werner;* Cobalt arsenical, *Hauy;* Octahedral Cobalt-Pyrites, *Mohs.*

Tesseral; chiefly the cube and octahedron, more rarely also ∞O and $2O2$. The most common combination is $\infty O\infty . O$; the faces of the cube being often somewhat convex. The crystals sometimes appear cracked; and are generally combined in druses. It also occurs reticulated, reniform, or botryoidal; or shows accidental specular faces; or is massive and disseminated, with a granular, compact, or rarely fine columnar texture. Cleavage, only in traces along $\infty O\infty$, and O. Fracture uneven. Brittle. H. = 5·5; G. = 6·4 — 7·3. Colour tin-white or steel-grey; with a dark grey or iridescent tarnish. Streak greyish-black. Lustre seldom very brilliant. Gives out an odour of arsenic when broken. In the open tube yields a crystalline sublimate of arsenious acid; in the closed tube gives no sublimate of arsenic. B.B. on charcoal fuses easily with a strong smell of arsenic to a white or grey magnetic globule, which, with borax, shows reaction for cobalt. Easily decomposed by nitric acid, and the solution when heated becomes red with a residue of arsenious acid. Chem. com. Co As, with 71·8 arsenic and 28·2 cobalt, but part of the latter often replaced by iron or nickel. Analyses.

	Cobalt.	Iron.	Nickel.	Copper.	Bismuth.	Arsenic.	Sulphur.	Total.	
1	20·31	3·42	...	0·16	...	74·22	0·89	99·00	Stromeyer, Riechelsdorf.
2	23·44	4·95	...	...	...	69·46	0·90	98·75	Varrentrapp, Tunaberg.
3	13·95	11·71	1·79	1·39	0·01	70·37	0·66	99·88	Hoffmann, Schneeberg.
4	9·44	18·48	...	trace	1·00	71·08	trace	100·00	v. Kobell, Do.
5	9·88	4·77	1·11	1·30	3·88	77·96	1·02	99·92	Kersten, Do.

Smaltine occurs in veins in granite, in the crystalline, transition, and secondary strata, with ores of silver and cobalt. Its chief localities are, Schneeberg, Marienberg, and Annaberg, in Saxony; Joachimsthal in Bohemia; Riechelsdorf in Hessia in the Kupferschiefer; Andreasberg in the Harz; Allemont in Dauphiné; Tunaberg in Sweden; Chatham in Connecticut; Wheal Sparnon, Doalcoath, and Redruth in Cornwall. The varieties with much iron, named from their colour grey smaltine, have a higher specific gravity (6·9 — 7·3) than the others, (only 6·3 — 6·6); and their solution in nitric acid gives a precipitate of iron peroxide. In a fibrous variety from Schneeberg, John found 28 cobalt, 65·75 arsenic, and 6·25 peroxide of iron and manganese, probably mixed. The *Wismuthkobaltkies* of Kersten, from Schneeberg No. 5, containing bismuth; and the *Yellow Smaltine* or *Kieskobold*, from Siegen, with pyrite, are probably mere mixtures. Smaltine and cobaltine are used in preparing blue colours for painting porcelain and stoneware, and one grain of the oxide will give a full blue to 240 grains of glass. The arsenic driven off during the roasting of the ores, is also collected.

407. MODUMITE, *N.*; Tesseralkies, *Breithaupt*; Hartkobalterz, *Hausmann*; Skutterudite, *Haidinger*.

Tesseral; O. and ∞O∞ with ∞O·and 2O2, or massive and granular. Cleavage, hexahedral distinct. Fracture conchoidal or uneven. Brittle; H. = 6; G. = 6·74 — 6·84. Colour between tin-white and pale lead-grey, sometimes with an iridescent tarnish. Lustre rather brilliant. In the closed tube it gives a sublimate of metallic arsenic; in the open tube a very large sublimate of arsenious acid. In other respects acts like smaltine. Chem. com. $Co^2 As^3$ with 79·2 arsenic and 20·8 cobalt. Analyses.

	Cobalt.	Iron.	Arsenic.	Sulphur.	Total.	
1	20·01	1·51	77·84	0·69	100·05	Scheerer.
2	18·5	1·3	79.2	...	99·0	Wöhler, crystallized.
3	19·5	1·4	79.0	...	99·9	Do. massive.

It occurs in a metaliferous bed in mica-slate at Skutterud, near Modum in Norway.

408. LINNÉITE, *Haidinger*; Sulphuret of Cobalt, *Phillips*; Kobaltkies, *Hausmann*; Isometric Cobalt-Pyrites, *Mohs*.

Tesseral. It occurs in octahedrons and cubes, the former sometimes macled by a face of O; also massive and disseminated. Cleavage, hexahedral imperfect; brittle. H. = 5·5; G. = 4·9 — 5·0.

Colour silver-white inclining to red, often with a yellowish or copper-red tarnish; streak blackish-grey. B.B. on charcoal evolves sulphurous vapours, and fuses in the reducing flame to a grey magnetic globule, bronze-yellow when broken. With fluxes shows reaction for cobalt. Soluble in warm nitric acid, with residue of sulphur. Chem. com. $Co\,S + Co^2\,S^3$, with 57·9 cobalt and 42·1 sulphur, but part of the former replaced by iron or copper. Analyses.

	Cobalt.	Iron.	Copper.	Sulphur.	Vein-stone.	Total.	
1	43·20	3·53	14·40	38·50	0·33	99·96	Hisinger, Riddarhytta.
2	43·86	5·31	4·10	41·00	0·67	94·94	Wernekink, Müsen.
3	53·35	2·30	0·97	42·52	...	98·87	Do. Do.

This mineral has been long known in Sweden, and is noticed by Linneus, hence the name given to it by Haidinger. It is found in a bed in gneiss with copper pyrites and hornblende at Bastnæs near Ridderhytta in Sweden; in veins in transition rocks, with various ores at Müsen near Siegen; and in the La Motte mine in Jefferson County in Missouri.

Syepoorite. This name may be given to a sulphuret of cobalt, probably a distinct species, found in primary rocks with pyrite and chalcopyrite at Syepoore near Rajpootanah in North West India. It is steel-grey or yellowish, with G. = 5·45, and contains, according to Middleton, 64·64 cobalt and 35·36 sulphur, or very nearly Co S. The Indian jewellers use it to give a rose colour to gold.

409. GRÜNAUITE, *N.;* Nickel Bismuth, *Dana;* Nickelwismuthglanz, *von Kobell, Mohs.*

Tesseral, O and $\infty O \infty$, in very small crystals. It also occurs granular and disseminated, Cleavage octahedral; brittle. H. = 4·5; G. = 5·14. Light steel-grey inclining to silver-white, with a yellow or greyish tarnish. B.B. on charcoal fuses to a brittle, magnetic bead, grey externally, and yellow on the fracture, and colours the support yellow; with borax shows the reaction for nickel. Soluble in nitric acid, with a residue of sulphur; the solution is green, and gives, when the free acid is removed, a precipitate with water. Von Kobell found 40·65 nickel, 14·11 bismuth, 38·46 sulphur, 3·48 iron, 0·28 cobalt, 1·68 copper, 1·58 lead (= 100·24), which subtracting the mixtures gives 45·40 nickel, 15·76 bismuth, and 38·84 sulphur (= 100). For this Frankenheim proposes the formula $\dot{N}i\,(\ddot{N}i''' \ddot{B}i''')$ (?) It occurs at Grünau in Sayn-Altenkirchen usually mixed with quartz.

410. GERSDORFFITE, *Löwe*, *Haidinger*; Nickel Glance, *Dana*; Nickelglanz, *Pfaff*, *Hausmann*; Nickelarsenkies, *Naumann*; Eutomous Cobalt Pyrites, *Mohs* in part.

Tesseral; O, ∞O∞, sometimes $\frac{\infty O2}{2}$. Usually it is massive and granular. Cleavage, hexahedral rather perfect. Fracture uneven. Brittle. H. = 5·5; G. = 6·0 — 6·13 (— 6·64 ?). Silver-white inclining to steel-grey, with a grey or greyish-black tarnish. In the closed tube decrepitates violently, and when strongly heated gives a large sublimate of yellowish-brown sulphuret of arsenic; the residue is red and acts like copper-nickel. Partially soluble in nitric acid, depositing sulphur and arsenious acid. Analyses.

	Nickl.	Arsenic.	Sulphur.	Iron.	Cobalt	Total.	
1	24·42	45·90	12·36	10·46	...	93·14	Pfaff, Loos, Sweden.
2	29·94	45·37	19·34	4·11	0·92*a*	100·58	Berzelius, Do.
3	27 *b*	48	14	11	...	100	Döbreiner, Camsdorf.
4	31·82	48·02	20·16	...	...	100	Rammelsberg, Lobenstein.
5	38·42	42·52	14·22	2·09	....*c*	99·12	Löwe (massive), Schladming, G. = 6·7 — 6·9.
6	26·14	49·83	14·13	9·55	...	99·65	Do. (cryst.) Do. (m. of 3)
7	19·59	39·04	16·35	11·13	14·12	100·23	Pless, Do. Do. G. = 6·64.
8	27·90	39·88	16·11	14·97	0·83	99·69	Do. Do. Do. Do.
9	28·62	39·40	16·91	12·19	2·88	100	Do. Do. Do. Do.
10	30·30	44·01	18·63	6·00	...*d*	100	Rammelsberg, Harzgerode, G. = 5·61 — 5·65.
11	28·75	46·10	16·25	8·90	...	100	Löwe, Prakendorf, Hungary.
12	37·34	45·34	14·00	2·50	trace *e*	100	v. Kobell (Amoibit).

(*a*) With copper + 0·90 silica; (*b*) with cobalt; (*c*) + 1.87 quartz; (*d*) + 0·86 antimony; (*e*) + 0·82 lead.

These analyses seem to admit of no common formula. Nos. 2, 4, 10 may be generally represented by (Ni Fe) (S^2, As), or Ni As + Ni S^2, with 35·5 nickel, 45·2 arsenic, and 19·3 sulphur, part of the nickel being replaced by iron or cobalt. No. 5, a massive variety, was probably impure, as No. 6 in crystals agrees tolerably with the general formula. Nos. 7, 8, 9, also from the same locality, are remarkable for containing cobalt, which has not been observed in this variety, either by Löwe or Rammelsberg. Including it with the iron and a part of the nickel, as R, the nearest formula would be Ni As + 2RS = 45·1 R or nickel, 38·5 arsenic, and 16·4 sulphur; but the variable amount of cobalt seems improbable in a crystallized mineral. Gersdorffite is used as an ore of nickel, and occurs near Harzgerode and Tanne in the Harz; Schladming in Styria, Camsdorf near Lobenstein in Thuringia, Loos in Helsingland, Sweden; also in Spain and Brazil.

The *Amoibite* of v. Kobell (No. 12 analysis) from Lichtenberg in the Fichtelgebirge, occurs in small octahedrons with a similar cleavage. Its colour is light steel-grey. H. = 4; G. = 6·08 or more. In

chemical action it resembles gersdorffite, but the analysis is nearer Ni^2 (As^3, S^3).

Tombazite, Breithaupt, from near Lobenstein, contains, according to Plattner, nickel, arsenic, and a little sulphur, with traces of cobalt and iron. It is bronze-yellow or pinchbeck-brown. H. = 4 — 5; G. = 6·637, and occurs in cubes with a hexahedral cleavage. Its true nature is still uncertain.

The *Wodankies*, in which Lampadius supposed he had found a new metal, Wodan, from Topschau in Hungary, probably belongs to the gersdorffite. Wackenroder describes a nickel-glance from Oelsnitz in the Voightlande as a new species, but the specimen analyzed was so impure as to admit of no certain result being deduced.

411. ULLMANNITE, *Fröbel, Haidinger;* Antimonial Nickel, *Phillips;* Nickel-Stibine, *Dana;* Antimonnickelglanz, *Hausmann;* Entomous cobalt pyrites, *Mohs* in part.

Tesseral; O, ∞O∞, ∞O; but usually massive and granular, or disseminated. Cleavage, hexahedral perfect. Fracture uneven. Brittle; H. = 5 — 5·5; G. = 6·2 — 6·5. Lead grey, inclining to tin-white or steel-grey; with a greyish-black or iridescent tarnish. In the open tube yields white antimony fumes and sulphurous acid. B.B. on charcoal fuses with dense fumes, and slight odour of arsenic. Soluble in concentrated nitric acid, with a residue of sulphur, antimony oxide, and arsenious acid. In nitrochloric acid forms a green solution, leaving sulphur. Chem. com. Ni Sb + Ni S^2 with 26·8 nickel, 58·6 antimony, and 14·6 sulphur, but part of the antimony often replaced by arsenic. Frankenhein's formula, $Ni^2(Sb, As, S)^3$, seems preferable, the last three elements being in indeterminate proportions. Analyses.

	Nickl.	Antimony.	Sulphur.	Arsenic.	Iron.	Total.	
1	25·25	47·75	15·25	11·75	...	100	Klaproth, Freusburg
2	23·33	61·68	14·16	...	...	99·17	John, Sayn-Altenkirchen.
3	26·10	47·56	16·40	9·94	...	100	Ullmann, Landskrone, Siegen.
4	27·36	55·76	15·98	...	...	99·10	H. Rose, Do.
5	28·04	54·47	15·55	...	...	98·06	Do. Do.
6	29·43	50·84	17·38	2·65	1·83	102·13	Rammelsberg, Harzgerode, G. = 6·506.

Stromeyer observed also traces of cobalt, iron, bismuth, and copper in this mineral. It is found chiefly in the copper mines in the transition rocks of the Westerwald, as at Gosenbach, Eisern, Freusburg, Landskrone in Siegen; and also at Harzgerode and Lobenstein.

412. BREITHAUPTITE, *Haidinger;* Antimonial Nickel, *Dana:* Antimon-nickel, *Hausmann.*

Hexagonal; P 112° 10′. The crystals, thin hexagonal tables of the combination 0P . ∞P, with the basis hexagonally striated, are generally small. It also occurs arborescent and disseminated. Fracture uneven or small conchoidal. Brittle; H. = 5; G. = 7·541 (*Breith.*) Lustre brilliant on 0P; colour light copper-red, with violet-blue tarnish. Streak reddish-brown. In the open tube it yields a sublimate of antimony. B.B. on charcoal the antimony volatilizes, leaving a white coating, and the nickel fuses with great difficulty. Soluble easily and entirely in nitrochloric acid. Chem. com. Ni^2Sb, with 31·4 nickel and 68·6 antimony. Analyses.

	Nickl.	Iron.	Antimony.	Sulphuret of lead.	Total.	
1	29·95	0·87	63·73	6·44	99·99	Stromeyer.
2	27·05	0·84	59.71	12·36	99·96	Do.
3	31·21	...	68·79	...	100	Mean of 1 and 2.

Occurs at Andreasberg in the Harz with ores of cobalt, lead, zinc, and pyrargyrite. The sulphuret of lead is probably a mixture.

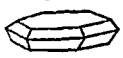
413. PLAKODINE, *Breithaupt.*

Rhombic; ∞P 115° 28′, P̆∞ 129° 52′ (monoclinohedric according to *Breit.*) The crystals usually of the combination ∞P̆∞ . ∞P . P̆∞ are tabular, attached, and sometimes intersecting. Cleavage, prismatic along ∞P, and brachydiagonal very imperfect. Very brittle; H. = 5 — 5·5; G. = 7·9 — 8·1. Bronze-yellow or light pinchbeck-brown, with black streak. In the open tube yields arsenious acid. B.B. on charcoal fuses readily with fumes of arsenic. The fused mass gives with borax at first the reaction for cobalt, but afterwards, with more borax, in the oxidating flame that for nickel. In nitric acid forms a green solution. Chem. com. essentially Ni^4As, with 61 nickel and 39 arsenic, or, by Plattner's analysis, 57·04 nickel, 0·91 cobalt, 0·86 copper, 39·71 arsenic 0·62 sulphur, and trace of iron (= 99·14). Some sulphuret of nickel and copper were also mixed with the specimen. It is found near Müsen in Siegen with siderite and gersdorffite.

414. NICKELINE, *Beudant;* Copper Nickel, *Allan;* Arsenical Nickel, *Phillips;* Nickel arsenical, *Hauy;* Kupfernickel, *Werner;* Prismatic Nickel Pyrites, *Mohs.*

Hexagonal; P 86° 50′, ∞P, 0P. The crystals (fig. 243) are very

Fig. 243.



rare, indistinct, and often mis-shapen. It also occurs reticulated, arborescent, spheroidal, or reniform; but generally massive and disseminated. Cleavage in very indistinct traces. Fracture conchoidal and uneven. Brittle. H. = 5·5; G. = 7·5 — 7·7. Light copper red, with a tarnish first grey then blackish. Streak brownish-black. It forms no sublimate in the closed tube. B.B. on charcoal fuses with strong arsenic fumes to a white, brittle, metallic globule. After being roasted, it shows with borax or salt of phosphorus reaction for nickel, and sometimes for cobalt. Soluble in concentrated nitric acid with deposition of arsenious acid, and more easily and completely in nitrochloric acid. Chem. com. Ni^2 As, with 44 nickel and 56 arsenic, but part of the latter often replaced by antimony. Analyses.

	Nickel	Cobalt.	Iron.	Lead.	Arsenic.	Antmony.	Sulphur.	Total.	
1	44·21	trace	0·34	0·32	54·72	...	0·40	99·99	Stromeyer, Riechelsdorf.
2	30·6	2·2	8·6	...	51·0	...	4·2a	97·0	Berthier, Zinkwand, Hungary.
3	39·94	0·16	...	...	48·80	8·00	2·00	99·90	Do. Altemont.
4	33·0	...	1·4	...	33·0	27·8	2·8b	100	Do. Balen, Pyrenees.
5	48·90	...	0·34	0·56	46·42	...	0·90	97·02	Pfaff, Riechelsdorf.
6	44·98	...	0·21	...	54·35	..	0·14c	99·79	Scheerer, Oestre Langoe, G. 7·663.

(*a*) + 0·4 veinstone; (*b*) + 2·0 quartz; (*c*) + 0·11 copper.

Nickeline occurs in veins, or rarely in beds, in granite, the crystalline, transition, and secondary strata, associated with cobalt, silver, and copper. It is found at Freiberg, Schneeberg, Annaberg, Marienberg in Saxony; Joachimsthal in Bohemia; Schladming in Styria; Andreasberg in the Harz; Chatham in Connecticut. Rarely in Cornwall, as at Pengelly and Huel-Chance; and at the Leadhills in Scotland. It is used as an ore of nickel, and in the manufacture of German silver.

415. RAMMELSBERGITE, *Haidinger;* White Nickel, *Dana;* Arsenik-nickel, *Rammelsberg.*

Tesseral; O, ∞O∞, ∞O. It also occurs massive and fine granular or compact; sometimes in columnar portions bounded by crystal-faces. Cleavage, mere traces; fracture uneven; brittle. H. = 5·5; G. = 6·4 — 7·2. Tin-white, but assumes first a grey, then a blackish tarnish, and loses its lustre. Sometimes covered by a green efflorescence of arseniate of nickel. Yields an odour of arsenic even when broken. In the closed tube forms a sublimate of metallic arsenic, and becomes copper-red. In the open tube yields arsenic and arsenious acid. B.B. on charcoal fuses easily with much smoke, continues long ignited, and becomes invested with crystals of

arsenious acid. At length leaves a brittle grain of metal, with green spots. Chem. com. Ni As, with 28·2 nickel and 71·8 arsenic. Analyses.

	Nickl.	Cobalt.	Iron.	Bismuth.	Copper.	Arsenic.	Sulphur.	Total.	
1	28·14	...	...	2·19	0·50	71·30	6·14	102·27	Hoffmann, Schneeberg.
2	20·74	3·37	3·25	...	...	72·64	...	1 ·00	Booth, Riechelsdorf.
3	28·40	...	trace	...	...	70·34	...	·74	Rammelsberg, Camsdorf, G. 6·735.
4	29·50	...	trace	...	...	70·93	...	100·43	Do. Do.

Breithaupt has recently divided this mineral into two species. The one is rhombic, in oblique prisms of 123° —124°, and G. = 7·099 — 7·188. Colour tin-white, inclining to red on the fresh fracture. It occurs at Schneeberg and Riechelsdorf, and is the variety analyzed by Hoffmann (No. 1). The other species is tesseral, as described above, and has G. = 6·432 — 6·565. It occurs in the same places, and is the variety analyzed by Booth (No. 2), perhaps also by Rammelsberg, from Camsdorf near Saalfeld. This compound is therefore dimorphous. Breithaupt names the former *Weissnickelkies*, and the latter *Chloanthite*; but it would be better to apply the latter term to the rhombic species, and retain Haidinger's name for the other.

416. MILLERITE, *Haidinger;* Sulphuret of nickel, *Phillips;* Haarkies, *Werner, Mohs;* Capillary Pyrites, *Dana;* Nickelkies, *Hausmann;* Nickel natif, *Hauy.*

Rhombohedric, in very fine acicular and capillary crystals, which, according to Miller, are hexagonal prisms with rhombohedric terminations, ∞P2 . R. Cleavage unknown. Brittle. H. = 3·5; G. = 5·26 — 5·28 (*Miller*). Colour brass or bronze-yellow, with a grey or iridescent tarnish. In the open tube yields sulphurous acid. B.B. on charcoal fuses easily to a blackish metallic globule, which boils and sputters, and acts with borax like nickel oxide. In nitro-chloric acid forms a green solution. Chem. com. Ni S, with 64·76 nickel and 35·24 sulphur. Analyses.

	Nickel.	Iron.	Copper.	Sulphur.	Total.	
1	64·35	...	...	34·26	98·61	Arfvedson.
2	61·34	1·73	1·14	35·79	100·00	Rammelsberg, Camsdorf, G. 5·65.

This mineral is rather rare, but it is found in veins in the secondary and crystalline rocks at Johann-Georgenstadt in Saxony; Jo-

achimsthal and Przibram in Bohemia; Camsdorf in Thuringia; Riechelsdorf in Hessia; in the Westerwald; near St Austle in Cornwall, and at Merthyr Tydvil.

417. Eisennickelkies, *Scheerer.*

Tesseral. It occurs massive and granular, with an octahedral cleavage. Fracture uneven; brittle. H. = 3·5 — 4; G. = 4·6. Light pinchbeck brown, with darker streak. Not magnetic. B.B. acts in general like pyrrhotine. The roasted powder forms with borax in the oxidating flame a glass coloured by iron; in the reducing flame a black opaque glass. Chem. com. 2 Fe S + Ni S, with 36 sulphur, 42 iron, and 22 nickel; or, by Sheerer's analysis, 40·21 iron, 21·07 nickel, 1·78 copper, and 36·64 sulphur (= 99·70). It occurs along with copper pyrites in a greenish-black hornblende near Lillehammer in Southern Norway.

418. Chalcopyrite, *Beudant;* Yellow Copper ore, Copper Pyrites, *Phillips;* Kupferkies, *Werner;* Cuivre pyriteux, *Hauy;* Pyramidal Copper Pyrites, *Mohs.*

Tetragonal and sphenoidal-hemihedric. The fundamental form P often appears as the sphenoid $\frac{P}{2}$ with the horizontal polar edges = 71° 20′; and still more frequently as $\frac{P}{2} \cdot -\frac{P}{2}$ (*P* and *P′*). Other common forms are P∞ (*b*), 2P∞ (*c*) 126° 11′, 0P (*a*), ∞P, ∞P∞, and many scalenohedrons. The crystals, generally small and deformed by the shortening or elongation of one side, are attached singly or in druses, fig. 244 being a very characteristic form. Macles are very common, according to various laws, as like fig. 245; and when repeated several times, obscure still more the forms of the single crystals. Most commonly it is found compact and disseminated, sometimes also

Fig. 244.

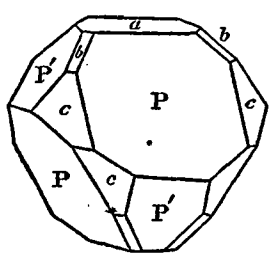
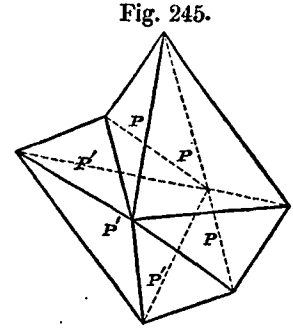


Fig. 245.



botryoidal and reniform. Cleavage, pyramidal along 2P∞ sometimes rather distinct. Fracture conchoidal or uneven. H. = 3·5 — 4; G. = 4·1 — 4·3. Colour brass-yellow, often with a gold-yellow or iridescent tarnish; streak greenish-black. B.B. on charcoal becomes darker or black, and on cooling red. Fuses easily to a steel-grey globule, which at length becomes magnetic, brittle, and greyish-red on the fractured surface. With borax and soda yields a grain of copper. In the open tube it evolves sulphurous acid, but no sublimate. Moistened with hydrochloric acid, it colours the flame blue. Soluble in nitrochloric acid, leaving sulphur, with more difficulty in nitric acid. Chem. com. essentially 1 atom copper, 1 atom iron, and 2 atoms sulphur, and hence either $\dot{C}u\,\dot{F}e$, or more probably $\dot{C}u\,Fe'''$, with 34·5 copper, 30·5 iron, and 35 sulphur. Analyses.

	Copper.	Iron.	Sulphur.	Quartz.	Total.	
1	34·40	30·47	35·07	0·27	101·01	H. Rose, Rammelsberg, Sayn.
2	33·12	30·00	36·52	0·39	100·03	Do. Furstenberg.
3	30·00	32·20	35·16	2·64	100	Phillips, Cornwall, crystallized.
4	31·20	30·80	34·46	1·10*a*	100	Do. Do. botryoidal.
5	33·3	30·0	32·0	2·6	97·9	Berthier, Saxony, massive.
6	32·1	31·5	36·3	...	99·9	Do. Allevard, Dept. Isère, Do.
7	31·2	32·2	33·6	1·6	98·6	Do.
8	22·96	42·51	34·75	... *b*	100·75	Scheidhauer (the Cuban).

(*a*) + 2·44 lead, arsenic, and loss; (*b*) trace of lead.

This is the most abundant of the ores of copper, and occurs in many localities and geognostic situations. It is the most common ore in the Cornish mines; and the varieties from Gunnis Lake and St Austle are remarkable for their splendid tarnish colours (peacock copper ores). In Scotland it occurs at many points on the shore of Kirkcudbright and Wigtonshires, at Tyndrum in Perthshire, in Inverness-shire, Zetland, and other places. Of foreign European localities, Fahlun, Roraas, Freiberg, Mansfeld, Goslar, Lauterberg, Musen, may be mentioned. It is common in Siberia, less abundant in the United States, and has recently been discovered in immense profusion in various parts of Australia. In 1847 there was raised in Cornwall and Devon 155,985 tons of copper ore, producing 12,754 tons of copper, worth L.889,287. This gives 8 per cent. metal on the average; and the ore picked for sale at Redruth rarely yields 12, sometimes only 3 or 4 per cent. In 1847 there was also sold at Swansea 746 tons of copper ore from other British mines, 14,373 tons from Irish mines, and 50,819 tons from foreign mines. In 1846 about 1700 tons of copper were exported from Russia.

"The richness of the ore," says Allan, "may in general be judged of by the colour; if of a fine yellow hue, and yielding readily to the hammer, it may be considered a good ore; but if hard and pale-yellow, it is assuredly a poor one, being mixed with iron pyrites.

The crystallized varieties are always rich. Though its colour is somewhat brighter than that of iron pyrites, the two may frequently be confounded; it yields, however, to the knife, which iron pyrites does not, and is decidedly softer than that mineral. Iron pyrites, moreover, most commonly occurs crystallized, copper pyrites rarely so. Iron pyrites is subject to decomposition, copper pyrites only to tarnish. Iron pyrites does not afford a green solution in nitric acid, while copper pyrites does so in a few minutes. From gold it is readily distinguished by its fracture and tenacity—it being brittle, whereas gold is malleable." This mineral is often mixed with iron pyrites, and occasionally contains a small proportion of silver or gold.

The *Cuban* of Breithaupt, only found massive, but with a hexahedral cleavage from Bacaranao in Cuba, has G. = 4·026 — 4·042, and agrees in general characters with chalcopyrite, but is more easily fusible. The analysis, No. 9 above, corresponds to one atom pyrrhotine (33·64) and two atoms chalcopyrite (66·61); and it is either a compound or mere mixture of these minerals.

419. BORNITE, *Haidinger;* Purple copper, *Phillips;* Buntkupfererz, *Werner*, *Allan;* Variegated copper, *Jameson;* Octahedral Copper Pyrites, *Mohs.*

Tesseral; $\infty O\infty$, and $\infty O\infty$. O occur, and also macles united by a face of O; but crystals are rare and generally with rough uneven faces. It is mostly found massive and disseminated. Cleavage, octahedral, but very imperfect. Fracture conchoidal or uneven. Slightly brittle, or almost sectile; H. = 3; G. = 4·9 — 5·1. Colour between copper-red and pinchbeck-brown, with very pale tarnish, especially steel-blue, inclining to red and green. Streak greyish-black. B.B. acts like chalcopyrite. Soluble in concentrated hydrochloric acid, leaving sulphur. Chem. com. of the crystallized varieties essentially 3 atoms copper, 1 atom iron, and 3 atoms sulphur, or $\dot{C}u^3\,Fe'''$, with 55·6 copper, 16·4 iron, and 28 sulphur, but often, especially in the compact varieties, mixed with chalcophyllite or copper glance. Analyses.

	Copper.	Iron.	Sulphur.	Quartz, &c.	Total.	
1	61·07	14·00	23·75	0·50	99·32	Phillips, Ross Island, Killarney.
2	71·00	6·41	22·58	..	99·99	Plattner, Sangershausen.
3	69 73	7·54	22·65	...	99 92	Do. Eisleben.
4	63·03	11·56	25·06	...	99·65	Do. Woitzkisch, White Sea.
5	56·76	14·84	28·24	...	99·84	Do. Condurra mine, Cornwall.
6	56·10	17·36	25·80	0·12	99·38	Do. Dalarne, Sweden.
7	58·20	14·85	26·98	...	100·03	Varrentrapp, crystallized.
8	63·33	11·80	24·70	...	99 83	Hisinger, Vestanforss.
9	62·75	11·64	25·70	0·04	100·13	Bodemann, Bristol, Connecticut.
10	57·89	14·94	26·84	0·04	99·71	Chodnew, Redruth, crystals.

Crystals of this mineral have only been procured in Cornwall, particularly at Tincroft and Dolcoath near Redruth. It occurs massive in rocks of various age in Norway, Sweden, Greenland, Silesia, Mansfeld (in the kupferschiefer), the Bannat, Tuscany, Siberia, and North America. It is used as an ore of copper.

420. DOMEYKITE, *Haidinger;* Arsenkupfer, *Zincken;* Arseniure de Cuivre, *Domeyko.*

Occurs botryoidal, reniform, or in thin veins, also massive and disseminated. Fracture uneven or conchoidal. Brittle; H. = 3 — 3·5. Colour tin or silver-white, inclining to yellow, or with an iridescent tarnish. Unchanged by ignition in a close vessel. B.B. fuses easily with strong odour of arsenic. Not affected by hydrochloric acid. Chem. com. Cu^6 As, with 71·63 copper and 28·37 arsenic. Analyses.

	Copper.	Iron.	Arsenic.	Sulphur.	Copper prot.	Arsenious acid.	Watr.	Total.	
1	71·65	...	28·36	...	...	...	...	100·01	Domeyko.
2	70·70	0·52	23·29	3·87	...	...	...	98·38	Do.
3	...	...	1·51	3·06	60·50	25·94	8·99	100	Faraday.
4	12·81	...	13·89	2·20	62·29*a*	3·70	5·83	100·72	Rammelsberg.
5	...	3·47*b*	...	...	79·00*a*	8·03	9·50	100	v. Kobell.
6	60·21	0·25	19·51	2·33	...	...*c*	2·41	100	Blyth.

(*a*) Sub-oxide; (*b*) peroxide; (*c*) + 15·29 organic matter = 1·62 carbon, 0·44 hydrogen, 0·06 nitrogen, and 13·17 oxygen.

No. 1 is the pure mineral from Calabazo in Coquimbo; No. 2 from the Antonio mine in Copiapo in Chili is mixed with chalcopyrite.

Nos. 3–6 are the *Condurrite* of Faraday, found in the Condurrow mine near Helstone, and more recently in the Wheal Druid at Carn Brae near Redruth, Cornwall. It is massive, soft, and soils the fingers, fracture flat conchoidal, colour brownish or bluish-black; G. = 4·20 — 4·29. In the closed tube it yields water and arsenious acid. B.B. on charcoal fuses with escape of arsenic vapours to a globule, which, on cooling, cracks, swells and falls to pieces. Treated with soda and borax, it leaves a grain of copper. In No. 4 the mineral was decomposed by hydrochloric acid, the metallic copper, arsenic, and sulphur, = 28·90, being undissolved. According to Rammelsberg, it is a mixture of red copper ore, arsenious acid, glance copper, and arsenic-copper, and is probably formed from the latter. No. 5 is an analysis of the portion soluble in hydrochloric acid by v. Kobell, who considers the remainder as finely-divided arsenic and a little sulphuret of copper. Dr Blyth has since examined this mineral, No. 6 being the composition of the mineral as a whole. He considers, from a mean of many analyses, that the original arsenid contained 71·15 copper, and 28·84 arsenic, and is consequently identical with the Domeykite, which may probably occur in the same mines.

421. ARSENIURET OF MANGANESE, *Kane.*

Massive and botryoidal, with a granular or foliated structure. Fracture uneven; brittle; G. = 5·55. Colour greyish-white, with a black tarnish. B.B. burns with a blue flame, and emits fumes of arsenic. Soluble in nitro-chloric acid. Chem. com. Mn As, according to Kane, who found 45·5 manganese, 51·8 arsenic, and trace of iron (= 97·3). It occurred on a mass of galena said to be from Saxony, but is very imperfectly known.

II. FAMILY.—LEAD GLANCE.

422. GALENA; Sulphuret of Lead, *Phillips;* Bleiglanz, *Werner;* Plomb sulfuré, *Hauy;* Hexahedral Lead-glance, *Mohs.*

Tesseral; usual forms ∞O∞, O, ∞O; seldom 2O, or other triakisoctahedrons, and 2O2, or other ikositetrahedrons. The most common combination is ∞O∞ . O; the crystals, of various sizes, are seldom perfectly formed, and occur rarely imbedded, mostly attached or in druses. The macles are conjoined by a face of the octahedron. It also forms metasomatic pseudomorphs after pyromorphite, or appears reticulated, cellular, corroded, tubular, botryoidal, or encrusting. It occurs most frequently massive and disseminated in granular, compact, or striated laminar aggregates. Cleavage, hexahedral very perfect, and hence the fracture is scarcely observable. Sectile. H. = 2·5; G. = 7·4 — 7·6. Colour lead-grey; when tarnished becomes darker, or rarely iridescent. Streak greyish-black. In the open tube it yields sulphur and a sublimate of sulphate of lead. B.B. on charcoal decrepitates, gives off sulphur, fuses, and leaves a globule of lead. Soluble in nitric acid, with evolution of nitrous acid and residue of sulphur. Nitr·-chloric acid changes it into sulphate and chloride of lead. Chem. com. essentially P'b, with 86·7 lead and 13·3 sulphur. Analyses.

	Lead.	Sulphur.	Silver.	Iron.	Zinc.	Total.	
1	83·0	16·41	0·08	...	...	99·49	Westrumb, Lauenstein, Hannover.
2	85·13	13·02	...	0·50	...	98·65	Thomson, Durham.
3	79·60	13·40	7·00	...	...	100	Beudant, Schemnitz.
4	84·63	13·21	...	...	...	97·84	Robertson, Inverkeithing, Scotland.
5	81·80	14·41	...	...	3·59	99·80	Lerch, Przibram (G. = 7·252).
6	83·61	14·18	...	...	2·18	99·97	Do. Do. (G. = 7·324).

Galena usually contains a small proportion of silver, in general from 0·01 to 0·03, or even 0·05 per cent.; very rarely 1 per cent.

or more. The pure galena ores in the Harz, with 60 — 71 per cent. lead, contain only 0·03 to 0·05 silver; the English lead ores only 0·02 to 0·03 per cent.; and those of the Leadhills in Scotland from 0·03 to 0·06 per cent. Some galena contains selenium, as, according to Berzelius, that from Fahlun and Åtwidaberg, and yields its peculiar smell when roasted on charcoal. Antimony and copper also occur in galena; and, in a variety from the Charente department in France, platina is said to have been found. The varieties Nos. 5 and 6 were parallel groups of very small cubical crystals, distinguished by their low specific gravity and the zinc, which in 5 is as 1 Zn to 8 Pb, in 6 as 1 to 12. The *supersulphuret* of lead from Dufton, with 90·38 sulphuret of lead and 8·71 sulphur (*Johnston*), and another from Ireland, with 98·21 sulphuret of lead and 1·79 sulphur (*Thomson*), are probably galena mixed with sulphur. The former burns even on exposure to the flame of a candle.

Galena is a very common mineral in rocks of all ages and formations. It is found in veins in gneiss at Freiberg; in mica-slate at Tyndrum in Perthshire; in transition or Silurian clay-slate and greywacke in the Harz, the Rhenish provinces, Styria, Wales, the Leadhills and other places in Scotland; in the Killas of Cornwall; in the carboniferous limestone of Derbyshire, Cumberland, and many parts of Scotland; in Wurtemberg in veins in the bunter Sandstein and Muschelkalk; in Carinthia, Galicia, and other parts of Austria in the Alpine limestone; in the Eifel disseminated through sandstone; at Linares in the Sierra Morena in veins in granite; in the Pentland hills in Scotland in claystone porphyry. In Missouri, Wisconsin, and the Western States of North America it occurs in immense abundance in the cliff limestone. Large crystals have been obtained at Dufton and Alston Moor in England; at Leadhills, Inverkeithing, and in Islay in Scotland; and the specular or slickenside variety at Castleton in Derbyshire and Allonhead in Durham. It forms the chief ore of lead in this country. In 1847 the produce of the United Kingdom was 83,747 tons ore, yielding 68 per cent. or 55,703 tons lead. Of the latter, England furnished 39,507½ tons, Wales 12,294 tons, Ireland 1380 tons, Scotland 822½ tons, and the Isle of Man 1699 tons.

423. CUPROPLUMBITE, *Breithaupt.*

Tesseral; but only found massive with a distinct hexahedral cleavage. Rather sectile and brittle. H. = 2·5; G. = 6·408 — 6·428. Colour blackish lead-grey; streak black. In the open tube fuses with effervescence, and emits sulphurous acid. B.B. on charcoal does not decrepitate, but covers the support with protoxide of lead and sulphate of lead. With soda gives a grain of metal. Chem. com-

$Cu\ Pb^2$ or, by Plattner's analysis, 64·9 lead, 19·5 copper, 0·5 silver, and 15·1 sulphur (=100). It is found in Chili, and mostly exported to England.

424. CLAUSTHALITE, *Beudant;* Selen-lead, Selenblei, *H. Rose, Mohs;* Seleniuret of Lead, *Phillips.*

Tesseral; but found massive and disseminated in small or fine granular aggregates, with a hexahedral cleavage. H. = 2·5 — 3; G. = 8·2 — 8·8. Colour lead-grey; streak grey. In the closed tube often decrepitates violently, in the open tube yields a grey or red sublimate of selenium. B.B. on charcoal fumes, smells of selenium, colours the flame blue, stains the support red, yellow, and white, and volatilizes, except a small remainder, without fusing. Soluble in nitric acid, leaving selenium. Chem. com. Pb Se, with 72·7 lead (partly replaced by silver) and 27·3 selenium. Analyses.

	Lead.	Cobalt.	Iron.	Silver.	Mercury.	Selenium.	Total.	
1	71·81	...	...	...	...	27·59	99·40	H. Rose, Tilkerode.
2	70·98	0·83	...	...	...	28·11	99·92	Stromeyer, Clausthal.
3	63·92	3·14	0·45	...	...	31·42	98·93	H. Rose, Tilkerode.
4	60·15	...	...	11·67	...	26·52	98·34	Rammelsberg, Do.
5	55·84	...	...	...	16·94	24·97	97·75	H. Rose, Do.
6	27·33	...	...	...	44·69	27·98	100	Do. Do.

Clausthalite occurs near greenstone (diabase) in the transition rocks of the Harz, usually with brown spar, as at Lerbach, Zorge and Tilkerode (rarely with gold and palladium). Also in a vein of brown spar at Reinsberg near Freiberg in Saxony. No. 3 is the *Selencobalt-lead* of the Germans, G. = 7·697, and known by colouring borax glass smalt-blue. It occurs near Clausthal in the Harz, and gives $Co\ Se^2 + 6\ Pb\ Se$. No. 4 is a selenid of silver and lead, but part of the selenium lost; it was examined for sulphur by R., but without success. Nos. 5 and 6, the *Selenquecksilberblei* of the Germans, the *Selenid of Mercury and Lead* of Dana, found at Lerbach and Tilkerode, seems a mere mixture of Selen-lead and Selen-mercury. In the closed tube it gives a sublimate of the latter, and with soda, mercury.

425. SELENCOPPERLEAD; Selenkupferblei and Selenbleikupfer, *H. Rose, Mohs, &c.;* Seleniuret of lead and copper, *Phillips.*

Massive and disseminated, with a small or fine granular texture. Sectile. H. = 2·5; G. = 7 — 7·5. Colour light lead-grey inclining to brass-yellow, or with a bluish tarnish. Streak darker. B.B. acts like clausthalite, only some fuse slightly on the surface, others (No.

1) easily forming a grey metallic mass. The residue shows reaction for copper. Chem. com., either Cu Se with 1, 2, or 4 atoms of Pb Se; or, more probably, as Frankenheim observes, indeterminate combinations of Cu^2 Se, and Pb Se, considered as isomorphous. Analyses.

	Lead.	Copper.	Silver.	Iron.	Iron perox.	Selenium.	Quartz.	Total.	
1	47·43	15·45	1·29	..	2·03*a*	34·26	...	100·51	H. Rose, Tilkerode.
2	59·67	7·86	....	0·33*b*	...	29·96	1.00*c*	99·26	Do. Do.
3	53·74	8·09	0·65	...*d*	2·00	30·00	4·50	98·31	Kersten, Glasbachgrunde.
4	63·82	4·00	0·07	traced	...	29·35	2·06	99·30	Do. Do.

(*a*) With lead; (*b*) + 0·44 iron and lead; (*c*) undecomposed mineral; (*d*) + traces of sulphur.

This mineral occurs with clausthalite at Tilkerode and Zorge in the Harz; at Glasbachgrunde near Gabel in Thuringia, in a vein in clay-slate; and also, it is said, at Reinsberg near Freiberg.

426. Onofrite, *Haidinger.*

Massive, and granular. H. = 2·5. Colour blackish lead-grey or steel-grey. Streak shining. In the closed tube wholly volatile with a black sublimate. With soda gives metallic mercury. Chem. com. Hg Se + 4 Hg S, corresponding to H. Rose's analysis, which gave 81·33 mercury, 6·49 selenium, and 10·30 sulphur (= 98·12). It occurs at St Onofre in Mexico with mercury in veins. A similar mineral seems to occur at Zorge in the Harz. Del Rio mentions other compounds of selenium and mercury as occurring at Culebras in Mexico, and one containing zinc (24 per cent.), but they are very imperfectly known. Zincken notices two minerals containing selenium, copper, and mercury, from Tilkerode, also little known.

427. Naumannite, *Haidinger;* Seleniuret of Silver, *Phillips:* Selensilber, *G. Rose, Mohs.*

Massive, and in thin plates with a granular texture. Cleavage, hexahedral perfect. Malleable. H. = 2·5; G. = 8. Colour and streak iron-black; lustre splendent. In the closed tube fuses with a slight sublimate of selenium and selenic acid. B.B. on charcoal in the oxidating flame fuses quietly, in the reducing flame boils, and when cooling ignites. With soda and borax gives a grain of silver. Easily soluble in concentrated nitric acid. Chem. com. Ag Se, with 73 silver and 27 selenium. G. Rose found 65·56 silver, 4·91 lead, and 29·53 selenium (= 100).

It occurs at Tilkerode in the Harz with clausthalite, and in small

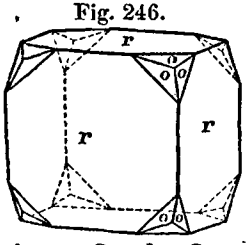
veins in greenstone. Del Rio mentions a double-selensilver as found at Tasco in Mexico. It is lead-grey, malleable, and crystallizes in six-sided tables.

The *Silverphyllinglanz* of Breithaupt, from gneiss at Deutsch-Pilsen in Hungary, is, according to Plattner, a mixture of selensilver and selenmolbdena, with a little gold. It occurs massive, in foliated aggregates, with a perfect cleavage in one direction, the thin lamina flexible. H. = 1 — 2; G. = 5·8 — 5·9. Colour dark drey.

428. ARGENTITE, *Haidinger;* Sulphuret of Silver, *Phillips;* Glaserz, *Werner;* Silberglanz, *v. Leonhard;* Argent sulfuré, *Hauy;* Hexahedral Silver Glance, *Mohs.*

Tesseral; usual forms $\infty O\infty$, O, ∞O, and 2O2 (fig. 246). The crystals are generally mis-shapen, with uneven or curved faces; the icositetrahedrons sometimes so drawn out as to appear like eight-sided pyramids. The crystals occur attached singly, but most commonly in druses, or in linear and stair-like groups; also arborescent, capillary, filiform, or reticulated. It also appears in crusts, or massive and disseminated. Cleavage, in very indistinct traces along ∞O and $\infty O\infty$. Fracture uneven and hackly; malleable and flexible. H. = 2 — 2·5; G. = 7 — 7·4. Lustre rarely brilliant, stronger on the streak. Colour blackish lead-grey, often with a black, brown, or rarely iridescent tarnish. B.B. on charcoal fuses, intumesces greatly with sulphurous fumes, and finally leaves a grain of silver. Soluble, with residue of sulphur, in concentrated nitric acid. Chem. com. $A'g$, with 87 silver and 13 sulphur. Klaproth found 85 silver and 15 sulphur (or, according to Beudant's calculation, 86·5 silver and 13·5 sulphur), in a variety from the Himmelsfurst mine near Freiberg, and 86·39 silver with 13·61 sulphur, in another from Joachimsthal in Bohemia.

Fig. 246.



Occurs chiefly in gneiss, in mica, hornblende and clay-slates, in granite, porphyry, and trachyte. It is found abundantly in Saxony, at Freiberg, Marienberg, Annaberg, Schneeberg, Johann-Georgenstadt; in Bohemia at Joachimsthal; in Hungary at Schemnitz and Kremnitz; in Norway at Kongsberg. More rarely at Andreasberg, in Wheal Duchy, Dolcoath, and other Cornish mines, and formerly at Alva in Stirlingshire. It is the common ore at Guanaxuato, Zacatecas, and other places in Mexico; in Peru, and at Blagodat in Siberia.

It is a valuable ore of silver, and so malleable, that King Augustus

of Poland coined medals out of some from the Saxon mines in its native state.

An earthy variety, the *Silberschwartz* or *Silbermulm* of the Germans, of a dark bluish-black colour, is found in several of the above localities.

429. STROMEYERITE, *Haidinger;* Sulphuret of Silver and Copper, *Phillips;* Silberkupferglanz, *Hausmann;* Isometric Copper Glance, *Mohs.*

Rhombic, and isomorphous with copper glance; crystals are rare, forming short prisms of ∞P . $\infty\breve{P}\infty$. $0P$. $\frac{1}{4}P$. $\frac{1}{2}\breve{P}\infty$. Usually massive, disseminated, or in plates. Cleavage not perceptible. Fracture flat conchoidal or even. Very sectile. H. = 2·5 — 3; G. = 6·2 — 6·3. Lustre bright; colour blackish lead-grey. B.B. fuses easily to a grey metallic, semimalleable globule; shows reaction for copper with fluxes, and on cupelation with lead leaves a grain of silver. Soluble in nitric acid with residue of sulphur. Chem. com. $\dot{C}u + \dot{A}g$, with 52·9 silver, 31·4 copper, and 15·7 sulphur. Analyses.

	Silver.	Copper.	Iron.	Sulphur.	Total.	
1	52·27	30·48	0·33	15·78	98·87	Stromeyer, Schlangenberg.
2	52·71	30·95	0·24	15·92	99·82	Sander, Rudelstadt.
3	28·79	53·38	...	17·83	100	Domeyko, S. Pedro, Chili.
4	24·04	53·94	2·09	19·93	100	Do. Catemo, Do.
5	16·58	60·58	2·31	20·53	100	Do. Do. Do.
6	12·08	63·98	2·53	21·41	100	Do. Do. Do.
7	2·96	75·51	0·74	20·79	100	Do. S. Pedro, Do.

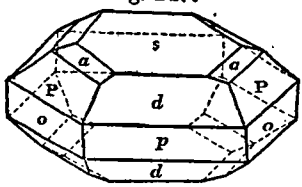
The analyses of Domeyko, and an earlier one of Lampadius, who found 18·5 sulphuret of silver in a copper glance from Freiberg, show that the two components occur in indeterminate proportions, and hence are probably isomorphous, and both also dimorphous.

It occurs massive with copper pyrites at Schlangenberg in Siberia; crystallized at Rudelstadt in Silesia; at Catemo in veins in porphyry with clay-slate. A variety with much iron is found at Combarvalla in Peru. It is used as an ore of silver and copper.

430. REDRUTHITE, *N.*; COPPER GLANCE; Vitreous Copper, Sulphuret of copper, *Phillips;* Kupferglanz, *Karsten;* Cuivre sulfuré, *Hauy;* Prismatic Copper Glance, *Mohs.*

Rhombic; ∞P (*o*) 119° 35′, P (*P*) with middle-edge 125° 22′; $\frac{1}{3}P$ (*a*) middle-edge 65° 40′; $2P\infty$ (*d*) middle-edge 125° 40′; $\frac{2}{3}\breve{P}\infty$ (*e*) middle-edge 65° 48′. The usual combinations are $0P$. (*s*) ∞P . (*e*) $\infty\breve{P}\infty$ (*p*), $0P$. $\frac{1}{3}\underset{\cdots}{P}$. $\frac{2}{3}\breve{P}\infty$, or these with other faces (fig. 247).

Fig. 247.



The crystals are mostly thick tabular, attached singly or in druses. The macles are united by ∞P; or by ½P when the tabular crystals intersect at an angle of 88°. Usually it occurs massive, disseminated, in plates or lumps. Cleavage, prismatic along ∞P imperfect. Fracture conchoidal or uneven; very sectile. H. = 2·5 — 3; G. = 5·5 — 5·8. Lustre rather dull; brighter on the streak. Colour blackish lead-grey, with a blue or other tarnish. B.B. colours the flame blue; on charcoal in the oxidating flame sputters and fuses easily; in the reducing flame becomes solid. With soda gives a grain of copper. Soluble in warm nitric acid, depositing sulphur. Chem. com. $c'u$, with 79·8 copper and 20·2 sulphur. Analyses.

	Copper.	Iron.	Sulphur.	Silica.	Total.	
1	76·50	0·50	22·00	...	99·00	Klaproth, Rothenburg.
2	78·50	2·25	18·50	0·75	100	Do. Katherinenburg.
3	79·50	0·75	19·00	1·00	100·25	Ulmann, Siegen.
4	77·16	1·45	20·62	...	99·23	Thomson, Cornwall.
5	77·76	0·91	20·43	...	99·10	Scheerer, Tellemark (G. = 5·795).
6	79·12	0·28	20·36	...	99·76	Do. Do. (G. = 5·521).

Hauy considered this mineral as hexagonal, but Mohs showed it to be rhombic. The crystals formed by fusing copper and sulphur are regular octahedrons, so that this substance must be dimorphous.

Occurs with various other ores of copper and iron in the metamorphic and stratified rocks, as at Freiberg in Saxony; Rudelstadt in Silesia; in Norway; the Bannat; Siberia, and the United States. Crystals are chiefly found in Cornwall, where very fine specimens have been obtained, especially in the mines near Redruth. Formerly at Frankenberg in Hessia it formed vegetable petrifactions, known as the *Frankenberg Corn-ears*, or *argent en epis*. In Scotland it occurs at Fassnet burn in Haddingtonshire, in Ayrshire, and in Fair Island, in small amount. It is one of the most important copper ores.

Digenite of Breithaupt occurs massive, with G. = 4·568 — 4·680, but in other respects agrees nearly with Redruthite. According to a blowpipe analysis of Plattner, it contains 70·20 copper, 29·56 sulphur, and 0·24 silver (= 100), or 3 $c'u$ + $c'u$. It is found at Sangerhausen in Thuringia and in Chili.

431. KUPFERINDIG, *Breithaupt, Phillips, Mohs;* Covelline, *Beudant;* Blue copper, *Dana.*

Hexagonal; ∞P . 0P, but crystals are rare. Usually it occurs

massive, reniform, and fine granular. Cleavage, basal often very perfect. Sectile, and thin laminæ flexible; H. = 1·5 — 2; G. = 3·8 — 3·85. Lustre dull resinous, inclining to metallic; brighter on the streak. Colour indigo-blue, inclining to black; streak black. B.B. burns with a blue flame; on charcoal acts like redruthite, but remains fluid in the inner flame. Soluble in nitric acid. Chem. com. Cu_2 with 66·7 copper, and 33·3 sulphur. Analyses.

	Copper.	Iron.	Lead.	Sulphur.	Total.	
1	64·77	0·46	1·05	32·64	98·92	Walchner, Badenweiler.
2	66·0	...	...	32·0	98·0	Covelli, Vesuvius.

Covelli found this mineral on slags in the crater of Vesuvius, where he says it is formed by the action of sulphuretted hydrogen on chloride of copper. It also occurs at Sangerhausen, in the mines near Badenweiler, in the Wilden Schapbach in the Schwarzwald; at Kielce in Poland, and crystallized with calc-spar on clay slate at Leogang in Salzburg. It differs in many respects from other metallic sulphurets.

432. EUKAIRITE, *Berzelius, Mohs;* Seleniuret of Silver and Copper, *Phillips;* Cuivre sélénié argental, *Hauy.*

Crystalline, but only massive and fine granular with indications of cleavage. Soft (cuts with the knife). Colour lead-grey. Streak shining. In the open tube forms a red sublimate of selenium and selenic acid. B.B. on charcoal fuses with sulphurous fumes to a brittle grey metallic grain. With borax or salt of phosphorus shows reaction for copper. With lead leaves a grain of silver. Soluble in nitric acid. Chem. com. $Cu^2 Se + Ag Se$, with 43 silver, 25·2 copper, and 31·8 selenium; or, by Berzelius' analysis, 38·93 silver, 23·05 copper, 26·00 selenium, and 8·90 earthy matter (= 96·88), which gives nearly 44·3 per cent. silver and 29·6 selenium. It occurs in a talcose or serpentine rock at the old copper mine of Skrickerum in Smoland. Its composition is analogous to that of stromeyerite, with the sulphur replaced by selenium.

433. BERZELINE, *Beudant;* Seleniuret of Copper, *Phillips;* Selenkupfer, *v. Leonhard, Mohs;* Cuivre sélénié, *Hauy.*

Crystalline, in thin dendritic crusts in fissures of calc-spar. Soft; colour silver-white; streak shining. In the open tube it forms a sublimate of selenium and selenic acid, leaving copper. B.B. on charcoal fuses to a grey, slightly malleable bead, giving out strong odours

of seleninm. With soda after long roasting yields a grain of copper. Chem. com. $Cu^2 Se$, with 61·5 copper and 38·5 selenium; or, by Berzelius' analysis, 64 copper and 40 selenium (= 104). It occurs at Skrickerum, in Smoland, Sweden; and rarely at the Caroline mine near Lerbach in the Harz.

434. NAGYAGITE, *Haidinger;* Black Tellurium, *Phillips;* Blättertellur, *Hausmann;* Foliated T., *Allan;* Nagyagererz, *Werner;* Tellure natif auro-plombifère, *Hauy;* Pyramidal Eutome-Glance, *Mohs.*

Tetragonal; P 140°, ¾P 122° 44'. The crystals tabular from predominance of 0P, occur attached, but are rare. In general only imbedded in thin plates or foliated aggregates. Cleavage, basal very perfect. Very sectile, the thin laminæ flexible. H. = 1 — 1·5; G. = 6·85 — 7·2. Lustre splendent. Colour blackish lead-grey. In the open tube emits sulphurous acid and a white sublimate. B.B. on charcoal fuses easily, with white fumes, and forms a yellow deposit on the support. After long heating, leaves a grain of gold. Soluble in nitric acid with residue of gold, and in nitrochloric acid, leaving chloride of lead and sulphur. Analyses.

	Lead.	Gold.	Silver.	Copper.	Tellurium.	Antimony.	Sulphur.	Total.	
1	54·00	9·00	0·50	1·30	32·20	...	3·00	100	Klaproth.
2	55·49	8·44	trace	1·14	31·96	...	3·07	100	Brandes.
3	63·10	6·70	...	1·00	13·00	4·50	11·70	100	Berthier.

From Klaproth's analysis, Berzelius considered this mineral as Pb Te, mechanically mixed with sulphuret of lead and tellur-gold. Berthier's analysis differs very widely. Petz has recently found 8.54, 7·81, and 6·48 per cent. gold, with none, or a mere trace of silver. It occurs in veins with gold and other ores at Nagyag in Siebenburg, and also at Offenbanya.

435. ALTAITE, *Haidinger;* Tellurblei, *G. Rose;* Hexahedral Tellurium, *Mohs.*

Tesseral; massive in granular aggregates, with hexahedral cleavage. Fracture uneven. Sectile. H. = 3 — 3·5; G. = 8·1 — 8·2. Colour tin-white inclining to yellow, with yellow tarnish. In the closed tube fuses, in the open tube forms round the assay a ring of white drops, and the fumes also form a white sublimate that is fusible. B.B. on charcoal colours the flame blue. In the reducing flame fuses to a globule that almost wholly volatilizes, whilst the assay becomes surrounded by a metallic shining ring, and at a greater distance

by a brownish-yellow, volatile deposit. Easily soluble in nitric acid. Chem. com. Pb Te, nearly agreeing with an approximative analysis by G. Rose, who found 60·35 lead, 1·28 silver, and 38·37 tellurium (= 100). It occurs mixed with tellur-silvér in the Sawodinski mine in the Altai mountains.

436. HESSITE, *Fröbel, Haidinger;* Tellur-silber, *G. Rose;* Telluric Silver, *Allan;* Uncleavable Tellurium, *Mohs.*

Occurs massive and granular, with mere traces of crystallization. Slightly malleable; H. = 2·5 — 3; G. = 8·31 — 8·83. Colour between blackish lead-grey and steel-grey. In the open tube it fuses, but does not fume, and gives only a very small sublimate of telluric acid. B.B. on charcoal fumes at a white heat, and leaves a rather brittle grain of silver. Ignited in the closed tube, with soda and charcoal powder forms telluride of sodium, which colours water deep-red. Soluble in warm nitric acid; from the solution telluriate of silver crystallizes after some time. Chem. com. Ag Te, with 62·8 silver, and 37·2 tellurium. Analyses.

	Silver.	Gold.	Iron.	Tellurium.	Total.	
1	62·42	...	0·24	36·96	99·62	G. Rose, Altai.
2	62·32	...	0·50	36·89	99·71	Do. Do.
3	61·55	0·69	...*a*	37·76	100	Petz, Nagyag (G. = 8·31 — 8·45.
4	46·76	18·26	...*a*	34·98	100	Do. Do. (G. = 8·72 — 8·83.

(*a*) Traces of iron, lead, and sulphur.

Occurs at the Sawodinski mine in the Altai with pyrite, cuprite, and blende in talc-slate, and at Nagyag in Siebenburg, and used as an ore of silver or of gold. No. 4 the *Tellurgoldsilber* of Hausmann, the *Petzite* of Haidinger, is the same species, with part of the silver replaced by gold.

437. TETRADYMITE, *Haidinger;* Telluric Bismuth, *Phillips;* Tellur-bismuth, *v. Leonhard;* Rhombohedric Eutome-Glance, *Mohs.*

Rhombohedric; R 66° 40′. The usual form is R . 0R. The crystals almost always form double or quadruple macles united by a face of ½R, and with the faces of 0R inclined at 95°. It also occurs massive and granular foliated. Cleavage, basal very perfect. Sectile, and in thin laminæ flexible; H. = 1 — 2; G. = 7·4 — 8·5. Lustre dull; colour between tin-white and steel-grey. B.B. on charcoal fuses easily, evolving sulphurous acid and occasionally odour of selenium, and staining the support yellow, and at some distance white; at length yields a white grain of metal, which can be almost entirely volatilized.

Soluble in nitric acid with residue of sulphur. Chem. com. 2 Bi Te^3 + Bi S^3, with 59·66 bismuth, 35·86 tellurium, and 4·48 sulphur. Analyses.

	Bismuth.	Tellur	Sulphur.	Selenium.	Veinstone.	Silver.	Total.	
1	60·00	34·60	4·80	traces	...	...	99·40	Wehrle, Schubkau.
2	58·30	36·05	4·32	...	0·75	...	99·42	Berzelius, Do.
3	61·15	29·74	2·33	...	...	2·07	95·29	Wehrle, Deutsch-Pilsen.
4	79·15	16·93	3·15	1·48	...	...	99·71	Damour, Brazil.
5	78·40	15·68	4·58		...	...	98·66	Do. Do.

The variety (1 and 2 above) from Schubkau near Schemnitz in Hungary, may be considered as a bismuth glance, in which part of the sulphur is replaced by tellurium. No. 3 from Deutsch-Pilsen in Hungary, the so-called *Molybdan-silver* of Werner, the *Elastic Eutome-glance* of Mohs, is probably distinct. It is light steel-grey, splendent metallic lustre, one cleavage very perfect, and a second nearly at right angles less perfect; the laminæ are slightly elastic; G. = 8·44; H. = 2·5. Nos. 4, 5 of a tellur-bismuth (the *Bornite*) found at Jose in Brazil in marble, give the formula 2 Bi Te + Bi S^2. It occurs in thin, slightly flexible, and very brilliant laminæ.

At Schubkau the tetradymite occurs in a fissure in a trachytic conglomerate; and at Pojana in Siebenburg in hornstone with gold and auriferous pyrites. A similar mineral is known at Tellemark in Norway, and Bastnaes near Riddarhyttan in Sweden.

438. MOLYBDENITE, *Beudant;* Sulphuret of Molybdena, *Phillips;* Molybdänglanz, *v. Leonhard;* Wasserblei, *Werner;* Molybdene, *Hauy;* Dirhombohedral Eutome-Glance, *Mohs.*

Hexagonal, but dimensions unknown, being only found tabular or in short prismatic crystals of 0P . ∞P, or 0P . P. Generally it occurs massive and disseminated, in scaly or curved foliated aggregates. Cleavage, basal very perfect. Very sectile, and thin laminæ flexible. Feels greasy. H. = 1 — 1·5; G. = 4·6 — 4·9. Colour reddish lead-grey. Makes a grey mark on paper, a greenish mark on porcelain. B.B. in the forceps, or on platina wire, colours the flame siskin-green, but is infusible. On charcoal yields sulphurous fumes, and forms a white coating, but burns slowly and imperfectly. It colours a bead of borax mixed with nitre, in the outer flame pale-brown, in the inner dark-brown. Decomposed by digestion in nitric acid, leaving a white powder of molybdic acid. In warm nitrochloric acid forms a greenish, in boiling sulphuric acid a blue solution. Chem. com. Mo'' with 60 molybdena and 40 sulphur. Analyses, next page.

	Molybdena.	Sulphur.	Vein-stone.	Total.	
1	60	40	...	100	Bucholz, Altenberg.
2	59·6	40·4	...	100	Brandes, Do.
3	59·42	39·68	...	99·10	Seybert, Chester, Pennsylvania.
4	58·63	40·57	0·80	100	Svanberg and Struve, Lindas.
5	57·15	39·71	3·14	100	Do. Do. Bohus.

In their corrected analyses, Svanberg and Struve find the sulphur in the variety from Lindas in three trials = 40·933, — 40·886, — 40·867; and in that from Bohus, 40·996; and from these and other experiments make the atomic number of molybdenum 575·829.

This mineral is common in small amount in various rocks, as granite, gneiss, and chlorite slate, and in veins with tin and other ores. It occurs crystallized at Arendal, Numedal in Sweden, Greenland, at Shutesbury in Massachusets, Brunswick in Maine, Haddam in Connecticut, and other places. Also massive at Altenberg, Ehrenfriedersdorf, Zinnwald, Schlackenwald, the Mont Blanc mountains, and other parts of the Alps. In England it is found with apatite in the granite of Caldbeckfell in Cumberland, Shap in Westmoreland, in Wheal Gorland, and in many other Cornish mines. In Scotland it has been found in granite at Peterhead, and at Corybuy on Loch Creran, and in chlorite slate in Glenelg. It much resembles graphite, but is readily distinguished by its streak, lustre, gravity, and action before the blowpipe. It is used for preparing the so-called blue carmine for colouring porcelain.

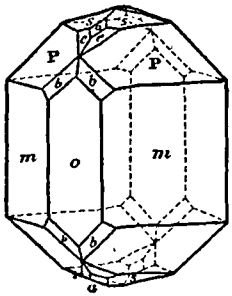
III. Family.—Grey Antimony Ore.

439. Stibine, *Beudant;* Sulphuret of Antimony, *Phillips;* Antimonglanz, *v. Leonhard;* Grauspiessglaserz, *Werner;* Antimoine sulfuré, *Hauy;* Prismatoidal Antimony Glance, *Mohs.*

Rhombic; P with polar edges 109° 16′ and 108° 10′, ∞P 90° 45′.

The usual combination is ∞P (*m*) . ∞P̆∞ (*o*) . P (*P*), either alone or with other forms, as ½P̆∞ (*a*), 2P̆2 (*b*), ⅔P̆2 (*e*), ½P (*s*) (fig. 248). The crystals, mostly long prismatic or acicular, with strong vertical striæ, are rarely distinctly formed or with perfect terminations. They are often combined in druses, or in diverging, stellar, or confused groups; and also occur massive and disseminated in radiating, fibrous, or fine granular aggregates. Cleavage, brachydiagonal (*o*) highly perfect, the cleavage faces often horizontally striated; also basal, prismatic along ∞P, and macrodiagonal, but all imperfect. Sectile.

Fig. 248.



H. = 2; G. = 4·6 — 4·7. Cleavage faces brilliant. Colour lead-grey, with a blackish or iridescent tarnish. B.B. fuses easily, colouring the flame green, and volatilizes, leaving a white coating on the support. In the open tube it yields a sublimate first of antimonious acid, and then of oxide of antimony. Soluble in warm hydrochloric acid, except a small residue of chloride of lime. Decomposed by nitric acid, with precipitation of antimony oxide; and also by solution of potash. Chem. com. Sb S^3, with 72·9 antimony and 27·1 sulphur. Analyses.

	Antimony.	Sulphur.	Total.	
1	74	26	100	Bergmann.
2	73·77	26·23	100	Thomson, Scotland.
3	74·06	25·94	100	Davy.
4	73·5	26·5	100	Brandes.

Antimony glance occurs in beds or veins in granite, the metamorphic and transition rocks, either alone, or with gold, silver, lead, and other ores. Its chief foreign localities are Bräunsdorf near Freiberg in Saxony; Wolfsberg in the Harz; Przibram in Bohemia; Felsöbanya, Kremnitz, Schemnitz, in Hungary; Auvergne in France; in Spain, and various places in North and South America. It is found massive at St Stephen's, Padstow, and Endellion in Cornwall; fibrous in greywacke at Glendinning in Dumfriesshire; and in granite in Banffshire. It is the chief ore of antimony.

440. JAMESONITE, *Haidinger*, *Phillips*; Axotomous Antimony glance, *Mohs*.

Rhombic; ∞P 101° 20′, other forms not accurately known. The crystals of the combination ∞F . ∞P̆∞ are long prismatic, in parallel or radiating groups. It also occurs massive and columnar. Cleavage, basal very perfect, prismatic along ∞P and brachydiagonal imperfect. Sectile. H. = 2 — 2·5; G. = 5·5 — 5·7. Steel-grey to dark lead-grey. B.B. decrepitates, fuses easily, and wholly volatilizes, except a small slag, which gives reaction for iron. Soluble in warm hydrochloric acid, with residue of chloride of lead. Chem. com. Pb'^3 Sb'''^2, with 43·7 lead, 36·1 antimony, and 20·2 sulphur. Analyses, next page.

	Lead.	Copper.	Iron.	Zinc.	Bismuth.	Antimony.	Sulphur.	Total.	
1	40·75	0·13	2·30	...	...	34·40	22·15	99·73	H. Rose, Cornwall.
2	38·71	0·19	2·65	0·74*a*	...	34·90	22·53	99·72	Do. Do.
3	39·92	...	3·63	0·42	1·06	32·62	21·78	99·48	Schaffgotsch, Spain.
4	43·44	0·18	0·16	...	...*b*	35·47	17·20	100·01	Pfaff, Nertschinsk.

(*a*) Lead containing iron and zinc; (*b*) + 3·56 arsenic.

Jamesonite occurs in considerable masses in Cornwall with quartz and bournonite; also at Valencia d'Alcantara in Estremadura in Spain; in Hungary; at Nertschinsk in Siberia; and Catta franca in Brazil.

The *Bleischimmer* of Pfaff, No. 4, from Nertschinsk, B.B. and with acids, acts like boulangerite; but the analysis is uncertain, and it is probably an arsenious jamesonite, or a mere mixture.

441. ZINCKENITE, *G. Rose*, *Phillips*; Bleiantimonerz, *Weiss*; Rhombohedral Dystome-Glance, *Mohs*.

Hexagonal; P 25° 24′ (*Naumann*). The usual combination is ∞P2 . P. The crystals, prismatic or acicular, vertically striated, and with three longitudinal furrows, or re-entering angles, are arranged in diverging groups or in druses; or form massive and columnar aggregates. Cleavage, prismatic but very imperfect. Fracture uneven. Rather sectile. H. = 3 — 3·5; G. = 5·30 — 5·35. Colour dark steel-grey to lead-grey, sometimes with a steel-blue or iridescent tarnish. B.B. decrepitates violently, fuses, emits fumes of antimony, and wholly volatilizes, except a small cupriferous remainder. In the open tube gives a sublimate of antimony oxide and antimoniate of lead. Soluble in warm hydrochloric acid, with residue of chloride of lead. Chem. com. $Pb' Sb'''$ with 35 lead, 43·4 antimony, 21·6 sulphur; or, by H. Rose's analysis, 31·84 lead, 0·42 copper, 44·39 antimony, 22·58 sulphur (= 99·23).

G. Rose and Hausmann consider this mineral as rhombic, the apparently hexagonal crystals being formed by a triple macle. Breithaupt and Haidinger regard it as rhombohedric.

It occurs at the Wolfsberg in the Harz, in a vein with stibine and quartz. Also, according to Walchner, near St Trudpert in the Schwarzwald.

442. PLAGIONITE, *G. Rose*, *Phillips*; Hemiprismatic Dystome Glance, *Mohs*.

Monoclinohedric; C = 72° 28′, P 134° 30′ and 142° 3′, —2P 120° 49′. Usual combination 0P . —2P . —P . P. The crystals are thick tabular, minute and grouped in small druses, or occur massive

and granular. Cleavage, hemipyramidal along —2P rather perfect. Brittle; H. = 2·5; G. = 5·4. Colour blackish lead-grey. B.B. decrepitates violently, fuses easily, sinking into the charcoal, and at length leaves metallic lead. In the open tube yields fumes of antimony and sulphurous acid. Chem. com. $Pb'^4\ Sb'''^3$ with 41 lead, 38·3 antimony, and 20·6 sulphur. Analyses.

	Lead.	Antimony.	Sulphur.	Total.	
1	40·52	37·94	21·53	99·99	H. Rose, Wolfsberg.
2	40·98	37·53	21·49	100	Kudernatsch, Do.

In chemical characters plagionite closely resembles jamesonite and zinckenite, and may be considered a compound of these two minerals. It was found at Wolfsberg in the Harz by Zincken, who named it *Rosenite*.

443. BOULANGERITE, *Thaulow*.

Occurs massive in fine granular, columnar, or parallel, radiating, or confused fibrous aggregates, and also compact. Slightly sectile; H. = 3; G. = 5·8 — 6. Lustre silky, inclining to metallic. Colour blackish lead-grey, with darker streak. B.B. fuses easily, evolving antimony vapours and sulphurous acid, and forming a coating of protoxide of lead. Partially soluble in nitric acid. Wholly in warm hydrochloric acid, with evolution of sulphuretted hydrogen. Chem. com. $Pb'^3\ Sb'''$, with 58 lead, 24 antimony, and 18 sulphur. Analyses.

	Lead.	Iron.	Copper.	Antimony.	Sulphur.	Total.	
1	53·9	1·2	0·9	25·5	18·5	100	Boulanger, Molières.
2	55·57	...	...	24·60	18·86	99·03	Thaulow, Nasafjeld.
3	56·29	...	...	25·04	18·22	99 55	Bromeis, Nertschinsk.
4	53·87	1·78	0·05*a*	23·06	19·11	98·47	Brüel, Do.
5	55·60	...	...	25·40	19·05	100·05	Abendroth, Ober-Lahr.
6	55·15	...	...	25·94	18·91	100	Rammelsberg, Wolfsberg, G. = 5·75*b*.

(*a*) Silver; (*b*) G. = 5·96 in powder.

This mineral occurs at Molières in the Gard department in France; at Nasafjeld in Lapland; at Ober-Lahr in Sayn-Altenkirchen, and near Nertschinsk in Siberia. The *Plumbostib* of Breithaupt, also from Nertschinsk, is of a lead or steel-grey colour, curved columnar structure, with a double cleavage; H. = 3·5; G. = 6·18. It contains 58·8 lead, with antimony, arsenic, and sulphur, and, according to Berzelius, is only boulangerite, the arsenic being probably accidental. The *Embrithite* of Breithaupt, from the same locality, in spheroidal,

fine granular masses of a lead-grey colour; H. = 2·5; G. = 6·29 — 6·31; contains, according to Plattner, 53·5 lead, 0·80 copper, 0·04 silver, with much antimony and sulphur, and is also probably boulangerite.

444. GEOKRONITE, *Svanberg.*

Rhombic; P with polar edges = 153° and 64° 45′, $\infty\breve{P}2$ = 119° 44′ (?) according to Kerndt. Crystals are very rare of the combination $\infty\breve{P}2$. $\infty\bar{P}\infty$. P. It mostly occurs massive, or compact with a striated or streaked lamellar structure. Cleavage prismatic along $\infty\breve{P}2$. Fracture conchoidal or even. Sectile. H. = 2 — 3; G. = 6·45 — 6·54. Colour pale lead-grey, with a slight tarnish. B.B. fuses easily and volatilizes, showing the reaction for antimony, lead, sulphur, and sometimes also for arsenic. Chem. com. $\dot{P}b^5$ ($\dot{Sb}'''$, $\dot{As}'''$). Analyses.

	Lead.	Copper.	Iron.	Antimony.	Arsenic.	Sulphur.	Total.	
1	66·45	1·51	0·42*a*	9·58	4·70	16·26	99·03	Svanberg, Sala.
2	64·89	1·60	...	16·00	...	16·90	99·39	Sauvage, Meredo, G. 6·43.
3	66·55	1·15	1·74	9·69	4·72	17·32	101·17	Kerndt, Tuscany, G. 6·45 — 6·47.
4	68·87	...	0·38	14·39	...	16·36	100	Apjohn, Kilbricken, G. 6·407.

(*a*) + 0·11 zinc, with traces of silver and bismuth.

Geokronite occurs in the silver mine of Sala in Sweden, at Mérédo in Galicia in Spain with galena (*Schulzite*); and crystallized at Val di Castello near Pietrosanto in Tuscany. The *Kilbrickenite* of Apjohn, No. 4, from county Clare in Ireland, seems a massive, granular, or foliated variety.

445. STEINMANNITE, *Zippe*, *Phillips;* Octahedral Lead Glance, *Mohs.*

Tesseral, usual form the octahedron. It also occurs in botryoidal and reniform aggregates with drusy surfaces, often showing distinct crystals. Cleavage hexahedral rather imperfect. Sectile. H. = 2·5; G. = 6·833, *Zippe.* Colour lead-grey. B.B. decrepitates violently. On charcoal fuses readily, evolving sulphurous acid and fumes of antimony, and leaving a grain of lead and silver. Chem. com. sulphurets of lead and antimony in unknown proportions.

It occurs with native silver, zinc-blende, pyrites, and quartz at Przibram in Bohemia.

446. PLUMOSITE, *Haidinger;* Feather ore, *Dana;* Federerz, *Werner;* Antimoine sulfuré capillaire, *Hauy.*

Crystallization unknown; occurs in acicular or capillary crystals,

united in felt-like masses. Almost sectile. H. = 1—3; G. = 5·7—5·9. Lustre dull or glimmering. Colour dark-lead or steel-grey, sometimes with an iridescent tarnish. B.B. and with acids acts like zinckenite. Fuses even in the flame of a candle. Chem. com. $P'_b{}^2\ Sb'''$ with 49·9 lead, 30·9 antimony, and 19·2 sulphur. Analyses.

	Lead.	Iron.	Zinc.	Antimony.	Sulphur.	Total.	
1	46·87	1·30	0·03	31·04	19·72	99·01	H. Rose, Wolfsberg.
2	48·48	...	...	32·93	20·32	101·73	Poselger, Do. G. 5·6788, massive.

It is found chiefly at Wolfsberg, but also at Andreasberg and Clausthal in the Harz, at the Pfaffenberg and Meiseberg near Neudorf in Anhalt, and at Freiberg and Schemnitz.

447. DUFRENOYSITE, *Damour;* Gotthardite, *Rammelsberg.* Tesseral; the crystals composed of ∞O . 2O2. Cleavage, not perceptible. Fracture uneven. Brittle. G. = 5·549. Colour steel-grey. Streak reddish-brown. In the closed tube gives a reddish-brown sublimate of sulphuret of arsenic. B.B. fuses easily, evolving sulphurous acid and arsenic fumes, and leaving a grain of lead. Slowly affected by hydrochloric acid, readily by warm nitric acid. Chem. com. $P'_b{}^2\ As'''$ with 57·12 lead, 20·74 arsenic, and 22·14 sulphur. Analyses.

	Lead.	Silver	Copper.	Iron.	Arsenic.	Sulphur.	Total.	
1	55·40	0·21	0·31	0·44	20·69	22·49	99·54	Damour.
2	56·61	0·17	0·22	0·32	20·87	22·30	100·49	Do.

This mineral is analogous in composition to plumosite, arsenic replacing the antimony, but the hair-like crystals of the latter can scarcely belong to the tesseral system. It is found in small veins in the dolomite of St Gotthardt with realgar, zinc-blende, and pyrite.

448. WOLFSBERGITE, *N.;* Antimonial Copper, *Dana;* Kupferantimonglanz, *Zinchen, Mohs.* Rhombic; ∞P 135° 12′, ∞P̆2 111°. The crystals are tabular from predominance of the brachypinakoid, and usually broken at the ends. It is also found massive, disseminated, and fine granular. Cleavage, brachydiagonal very perfect, basal imperfect. Fracture conchoidal or uneven; H. = 3·5; G. = 4·748. Colour lead-grey to iron-black, sometimes with an iridescent tarnish. Streak black, dull. B.B. decrepitates, fuses easily, on charcoal emits fumes of antimony, and

after long fusion with soda gives a grain of copper. Chem. com. $\dot{C}u\ \ddot{S}b'''$ with 24·9 copper, 50·2 antimony, and 24·9 sulphur; or, by H. Rose's analysis, 24·46 copper, 1·39 iron, 0·56 lead, 46·81 antimony, and 26·34 sulphur (= 99·56). It is found at Wolfsberg in the Harz imbedded in quartz.

449. KERMES, *Beudant;* Antimonblende, *v. Leonhard;* Red Antimony, *Phillips;* Rothspiessglaserz, *Werner;* Antimoine oxydé sulphuré, *Hauy;* Prismatic Purple Blende, *Mohs.*

Probably monoclinohedric (*Naumann, Mohs*). The crystals are acicular or capillary, and form diverging groups. It also occurs massive and disseminated with a radiating fibrous texture. Cleavage, very perfect along the axis of the crystals, less perfect at right angles to it. Sectile; H. = 1 — 1·5; G. = 4·5 — 4·6. Semitransluscent; lustre adamantine; colour cherry-red; streak similar. B.B. acts like antimonite. Soluble in hydrochloric acid, evolving sulphuretted hydrogen. In solution of potash the powder becomes yellow, and then wholly dissolves. Chem. com. $\ddot{S}b'''^2\ \dot{S}\ddot{b}$, with 76·3 antimony, 19·0 sulphur, and 4·7 oxygen; or 69·8 sulphuret and 30·2 protoxide of antimony. H. Rose in three trials found 75·06 antimony, 4·78 oxygen, and 20·49 sulphur (= 100·33).

It is found in veins with antimonite and quartz, especially at Bräunsdorf near Freiberg in Saxony; also at Michelsberg and Przibram in Bohemia, and Allemont in Dauphiné.

The so-called *Zundererz* or Tinder-ore occurs in soft, flexible, tinder-like masses, of a dirty cherry-red or blackish-red colour, and little lustre. Bornträger found, in a variety from Andreasberg, 2·56 silver, 43·06 lead, 4·52 iron, 16·88 antimony, 12·60 arsenic, 19·57 sulphur (= 99·19). Hence it is not kermes as was generally supposed, but apparently a mixture, and, as shown by calculation, probably of plumosite (82·04 per cent.), mispickel (13·46), and pyrargyrite (4·34).

450. BERTHIERITE, *Haidinger, Phillips, Mohs;* Haidingerite, *Berthier?*

Crystallization unknown. It is found massive with a columnar or fibrous texture, and distinct cleavage in several directions; H. = 2 — 3; G. = 4·0 — 4·3 (4·284 *Breit.*). Colour dark steel-grey, sometimes yellowish or reddish; very subject to tarnish. B.B. on charcoal fuses easily, evolving fumes of antimony, and at length leaves a black magnetic slag, which shows reaction for iron, and in some specimens for manganese. Soluble in hydrochloric, and more readily in nitrochloric acid. Analyses, next page.

	Antimony.	Iron.	Zinc.	Manganese	Sulphur.	Total.	
1	52·0	16·0	0·3	...	30·3	98·6	Berthier, Chazelles.
2	54·34	11·96	trace	0·46	30·58	97·84	Rammelsberg, Bräunsdorf.
3	54·70	11·43	0·74	2·54	31·33	100·74	Do. Do.
4	58·65	12·17	...	...	29·18	100	Berthier, Anglar.
5	61·34	9·85	...	...	28·81	100	Do. Martouret.

These analyses show that Berthierite consists of sulphuret of antimony Sb''', and sulphuret of iron $F'e$ in various proportions, or in No. 1 as 2 : 3 atoms; in Nos. 2, 3, 4, as 1 : 1; and in No. 5 as 4 : 1. It occurs at Chazelles and Martouret in Auvergne, at Anglar in the dept. de la Creuse in France, at Braunsdorf in Saxony, and in veins at Tintagel and Padstow in Cornwall. In France it is used as an ore of antimony.

451. BISMUTHINE, *Beudant;* Sulphuret of Bismuth, *Phillips;* Wismuthglanz, *Werner, &c.;* Bismuth sulfuré, *Hauy*; Prismatic Bismuth-glance, *Mohs.*

Rhombic; ∞P 91° 30′. The crystals are long prismatic or acicular, with strong longitudinal striæ, and generally imbedded. It also occurs massive and disseminated in granular or columnar aggregates with a foliated or radiated texture. Cleavage, brachydiagonal perfect, macrodiagonal less distinct, basal and prismatic along ∞P imperfect. Sectile; H. = 2 — 2·5; G. = 6·4 — 6·6. Colour light lead-grey inclining to tin-white, with a yellowish or iridescent tarnish. In the open tube yields a sublimate of sulphur, with odour of sulphurous acid, and at length boils. B.B. on charcoal fuses easily in the inner flame, sputters, and yields a yellow coating with a grain of bismuth. Soluble in nitric acid, with residue of sulphur. Chem. com. Bi''' with 81·5 bismuth and 18·5 sulphur. Analyses.

	Bismuth.	Iron.	Copper.	Sulphur.	Total.	
1	80·98	...	...	18·72	99·70	H. Rose, Riddarhyttan.
2	80·96	...	...	18·28	99·24	Wehrle, Retzbanya.
3	72·49	3·70	3·81	20·00	100	Warrington, Cornwall.
4	79·77	0·15	0·14	19·12	99·18	Scheerer, Gjellebäk, Norway.
5	74·55	0·40	3·13*a*	19·47	100·35	Hubert, Orawitza.

(*a*) + 2·27 lead and 1·23 gold.

Bismuthine is rather rare, and occurs chiefly in the crystalline schists or granite; as in beds with cererite at Riddarhyttan, Bastnaes, and other parts of Sweden; in veins especially of quartz along with bismuth, galena, and copper ores, at Johann-Georgenstadt, Altenberg, and Schneeberg in Saxony; Joachimsthal in Bohemia; and at

Haddam in Connecticut. It occurs in small brilliant tin-white crystals at Wheal Sparnon near Redruth, yellowish-white at Botallack near the Land's End, also in Dolcoath and Herland in Cornwall, and foliated at Caldbeckfell in Cumberland.

452. ACICULITE, *N.*; Needle-ore, *Phillips*; Nadelerz, *Werner, Mohs;* Bismuth sulfuré plumbo-cupriféré, *Hauy;* Prismatoidal Bismuth-Glance, *Mohs.*

Rhombic; but dimensions unknown. It occurs imbedded in quartz in long thin crystals, often bent or broken, marked with strong vertical striæ, and forming apparently four or six-sided prisms. Cleavage along one vertical plane. Fracture conchoidal or uneven. Rather brittle. H. = 2·5; G. = 6·7 — 6·8. Colour blackish lead-grey or steel-grey, with a brownish tarnish. B.B. fuses very easily, smokes, covers the charcoal with a white and yellow coating, and leaves a metallic globule, which yields with soda a grain of copper. In the open tube evolves sulphurous acid and white fumes, which partly condense into clear drops. Soluble in nitric acid, leaving sulphate of lead and a little sulphur. Chem. com. $\dot{P}b^4\,\ddot{B}i''' + \dot{C}u^2\,\ddot{B}i'''$, with 35·8 lead, 11 copper, 36·7 bismuth, and 16·5 sulphur. Analyses.

	Copper.	Lead.	Bismuth.	Sulphur.	Total.	
1	11·79	35·69	34·62	16·05	98·15	Frick, Beresow.
2	10·59	36·05	36·45	16·61	99·70	Do. Do.

John found nickel, tellurium, and gold in this mineral, but his analysis was very imperfect. It occurs in several mines near Beresow in Siberia, imbedded in quartz along with native gold.

453. KOBELLITE, *Setterberg.*

Occurs massive with a radiated columnar texture. Soft and easily cut with a knife. G. = 6·29 — 6·32. Colour blackish lead-grey to steel-grey; streak black; in the closed tube yields sulphurous acid and antimony oxide. B.B. fuses (at first boiling, then quietly), and stains the charcoal white and yellow, and leaves a white grain of metal. Soluble in concentrated hydrochloric acid, evolving sulphuretted hydrogen. Chem. com. $3\,\dot{P}b^3\,\ddot{B}i''' + \dot{F}e^3\,\ddot{S}b'''^2$, which gives 46 sulphuret of lead, 33·3 sulphuret of bismuth, 5·7 sulphuret of iron, and 15 sulphuret of antimony; or, by Setterberg's analysis, 9·24 antimony, 40·12 lead, 27·05 bismuth, 2·96 iron, 0·80 copper, 17·86 sulphur, and 1·45 veinstone (= 99·48). It occurs in the cobalt mine of Hvena, in Nerike in Sweden. The copper pyrites is only mixed, as it appears in fine disseminated grains under the microscope.

454. SILVANITE, *Haidinger;* Schrifterz, *Naumann;* Schrifttellur, *Hausmann;* Prismatic Antimony-Glance, *Mohs.*

Rhombic. The crystals are sometimes exceedingly complex, but are generally very small, short acicular, and often grouped in rows in one plane at angles of about 60°, forming triangular figures like letters. Cleavage, in two directions nearly at right angles, one very perfect. Sectile, but the thin laminæ friable. H. = 1·5 — 2; G. = 7·99 — 8·33. Colour light steel-grey to tin-white, silver-white, and pale bronze-yellow. In the open tube leaves a sublimate of telluric acid. B.B. on charcoal forms a white coating, and fuses to a dark-grey globule, which at length (more readily with soda) is reduced to a malleable grain of argentiferous gold. Soluble in nitro-chloric acid, depositing chloride of silver; and in nitric acid, leaving gold. Chem. com. $Ag\,Te^4 + Au\,Te^3$, with 59·6 tellurium, 26·5 gold, and 13·9 silver; but sometimes the silver is partly replaced by lead, the tellurium by antimony. Analyses.

	Gold.	Silver.	Lead.	Tellurium.	Antimony.	Total.	
1	30·00	10·00	...	60·00	...	100	Klaproth, Offenbanya.
2	26·75	8·50	19·50	44·75	....*a*	100	Do. Nagyag.
3	26·97	11·47	0·25	59·97	0·58*b*	100	Petz, Offenbanya, acicular cryst., G. 8·28.
4	26·47	11·31	2·75	58 81	0 66	100	Do. Do. indistinct cryst., Do.
5	24·89	14 68	2·54	55·39	2·50	100	Do. Nagyag, long white cryst., G. 8·27.
6	29·98	10·69	3·51	48·40	8·42	100	Do. Do. thick white cryst., G. 7·99.
7	27·10	7·47	8·16	51·52	5·75	100	Do. Do. short yellow cryst., G. 8·33.
8	25·31	10·40	11·21	44·54	8·54	100	Do. Do. massive pale yellow.
9	29·62	2·78	13 82	49·96	3·82	100	Do. Do. Do. Do.

(*a*) + 0·50 sulphur; (*b*) + 0·76 copper.

This mineral was formerly divided into two species, the variety from Offenbanya being named *Schrifterz* (Werner) or *Graphic Tellurium* (Phillips); that from Nagyag, the *Weiss Sylvanerz* (Werner) or *Yellow Tellurium* (Phillips). Haidinger still distinguishes the latter as *Mullerine*, and assigns to it different angular dimensions. They, however, agree chemically, and probably also mineralogically. It is found in small veins in porphyry with quartz and gold at the above places in Siebenburg, and used as an ore of the precious metals.

IV. Family.—Grey Copper Ore.

455. Fahlore, *N.;* Grey copper, *Phillips;* Fahlerz, *Werner;* Cuivre gris, *Hauy;* Tetrahedral Dystome-glance, *Mohs.*

Tesseral, and tetrahedral semitesseral. The usual forms are $\frac{O}{2}$, $-\frac{O}{2}$, ∞O, $\frac{2O2}{2}$, and others. The combinations are numerous, but in general either the tetrahedron, or the trigonal, or rhombic dodecahedron, appear as the prevailing form (fig. 249). Macles (fig. 250) are

Fig. 249.

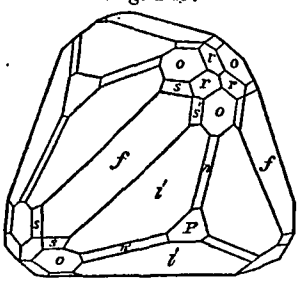
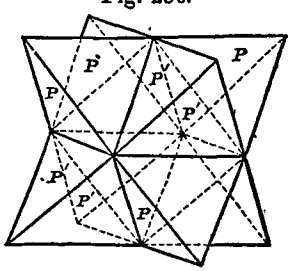


Fig. 250.



not uncommon. It is most abundant, massive and disseminated. Cleavage, octahedral imperfect, with traces in other directions. Fracture conchoidal to uneven, or fine granular. Brittle. H. = 3 — 4; G. = 4·3 — 5·2. Colour steel-grey to iron-black. Streak black, or dark-red in the variety containing zinc. Roasted in the open tube it yields fumes of antimony, sulphurous acid, and sometimes arsenic. B.B. on charcoal boils slightly, and fuses to a steel-grey slag, usually magnetic, and with borax yields a grey metallic grain, which with soda gives copper. In nitric acid the powder forms a brownish-green solution, with evolution of nitrous acid, and a residue of antimony oxide, often also of arsenious acid and sulphur. Caustic potash partially decomposes the powder, the sulphuret of antimony and sulphuret of arsenic being dissolved, and thrown down by acids as an orange or citron-yellow precipitate. Chem. com. very variable, but generally $(\dot{C}u, \dot{A}g, \dot{F}e, \dot{Z}n, \dot{H}y)^4 (\ddot{S}b, \ddot{A}s)$, *Frankenheim.* The pale varieties (*Graugiltigerz*) generally contain a large proportion of arsenic, sometimes even with no antimony; the dark varieties (*Schwarzgiltigerz*), on the other hand, less or no arsenic. Analyses, next page.

	Sulphur.	Antimony.	Arsenic.	Copper.	Iron.	Zinc.	Silver.	Total.	
1	25·77	23·94	2·88	37·98	0·86	7·29	0·62	99·34	H. Rose, Kapnik, Hungary.
2	26·33	16·52	7·21	38·63	4·89	2·76	2·37	98·71	Do. Gersdorf, Freiberg.
3	26·83	12·46	10·19	40·60	4·66	3·69	0·61*a*	99·44	Do. Markirchen, Alsace.
4	25·03	25·27	2·26	39·42	1·52	6·85	0·83	100·18	Do. Dillenburg, Nassau.
5	24·73	28·24	...	34·48	2·27	5·55	4·97	100·24	Do. Clausthal.
6	23·52	26 63	...	25·23	3·72	3·10	17·71	99·91	Do. Wolfach.
7	21·17	24·63	...	14·81	5·98	0·99	31·29	98·87	Do. Freiberg.
8	23·76	25·97	...	37·11	4·42	5·02	1·09*b*	98·38	Bromeis, Durango, Mexico.
9	23·34	18·48	3·08	35 90	4·20	1·01	traces *c*	97·86	Scheidthauer, Iglo, Hungary.
10	24·17	27·47	...	35·80	1·89	6·05	0·33*d*	98·41	Kersten, Val di Castello.
11	24·1	26·8	...	35·7	4·5	...	8·9 *e*	100·9	Sander, Clausthal.
12	23·73	28·87*f*	...	35·78	5·03	3·59	...	100	Amelung, Camsdorf.
13	23·40	27·47	...	35·90	1·93	6·24	0·33*g*	100	Kersten, Angina, Tuscany.

(a) + 0·41 quartz; *(b)* + 0·54 lead and 0·47 undecomposed mineral; *(c)* with lead + 7·52 mercury and 2·73 quartz; *(d)* + 2·70 mercury; *(e)* + 0·9 lead; *(f)* with a little arsenic; *(g)* + 2·70 mercury, and 2·03 veinstone, and loss.

Nos. 1–7, 11, were crystallized; Nos. 8, 12, massive; No. 13 had G. = 4·84, and, in a separate trial, the silver was found = 0·204 per cent., the gold = 0·0066 per cent. In a variety from Poratsch in Hungary, Klaproth found 6·25 mercury; and this metal also occurs in that from Moschellandsberg. Vauquelin says he found platina in a variety from Guadalcanal in Estremadura. The varieties with much silver, like Nos. 6, 7, are the *Weissgiltigerz*, or silver-fahlore, chiefly from Freiberg. Lead seems a very rare component of this mineral, that in Nos. 8, 9, 11 being probably incidental. There are very many other analyses of this mineral, but the older ones are generally imperfect.

The above are some of the chief foreign localities of this important ore. The largest crystals are, however, from the Cornish mines, especially Crinnis and others near St Austle. In Scotland it occurs in small amount in a few places, as at Airthrie near Stirling, and Sandlodge in Zetland.

456. TENNANTITE, *Phillips;* Dodecahedral Dystome-Glance, *Mohs.*

Tesseral; resembling fahlore in forms, combinations, and macles. Cleavage dodecahedral along ∞O, very imperfect. Brittle; H. = 4; G. = 4·3 — 4·5. Colour blackish lead-grey to iron-black; streak dark reddish-grey. B.B. decrepitates, burns with a bluish flame and odour of arsenic, and fuses to a magnetic slag. Chem. com. $(Cu\,Fe)^4\,As'''$, and consequently an arsenical fahlore. Analyses.

	Sulphur.	Arsenic.	Copper.	Iron.	Zinc.	Silver.	Total.	
1	30·25	12·46	47·70	9·75	...	...	100·16	Phillips, Trevisane, Cornwall.
2	27·76	19·10	48·94	3·57	...	traces*a*	99·45	Kudernatsch, Do.
3	29·18	19·01	42·60	9·21	...	..	100	Fearnley, Skutterud, G. = 4·53.
4	28·11	18·88	41·07	2·22	8·89	traces*b*	99·51	Plattner, Freiberg.

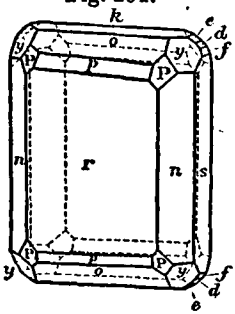
(a) + 0·08 quartz; *(b)* with antimony, + 0·34 lead.

Tennantite occurs in veins at Wheal Jewel and Wheal Unity near Redruth and St Days in Cornwall. No. 3 is a similar mineral from Norway. No. 4 is the *Kupferblende* of Breithaupt, distinguished by its brownish-red or dirty cherry-red streak and lower specific gravity = 4·2 — 4·4; and by a portion of the copper being replaced by zinc. Properly these minerals are only varieties of fahlore.

457. BOURNONITE, *Jameson*, *Phillips*; Schwarzspiessglaserz, *Werner*; Antimoine sulfuré plumbo-cuprifére, *Hauy*; Diprismatic Dystome-Glance, *Mohs*.

Rhombic; ∞P 93° 40′, P̆∞ 96° 31′, P̄∞ 92° 52′. The most common combination is 0P (*r*) . ∞P (*d*) . ∞P̆∞ (*s*) . P̆∞ (*n*) . ∞P̄∞ (*k*) . P̄∞ (*o*); often with other faces, as in fig. 251, of a common form from Cornwall. The crystals are generally thick tabular, and very often macled, by a face of ∞P, and several times repeated. It also occurs massive in granular aggregates, or disseminated and investing. Cleavage, brachydiagonal imperfect; macrodiagonal more indistinct; and traces only in other directions. Fracture uneven to conchoidal; rather brittle; H. = 2·5 — 3; G. = 5·7 — 5·9. Lustre brilliant metallic. Colour steel-grey, inclining to lead-grey and iron-black. B.B. usually decrepitates and fuses easily, on charcoal at first fumes and then forms a black globule, which in a stronger heat colours the support first white, then yellow, and on removal of the lead by soda leaves a grain of copper. In the open tube evolves sulphurous vapours and white fumes, depositing above antimony oxide (volatile), on the lower side antimoniate of lead (not volatile and infusible). In nitric acid it forms a blue solution with residue of sulphur and oxide of antimony. Nitrochloric acid separates sulphur, chloride of lead, and antimoniate of lead. Chem. com. $P'b^4\,Sb''' + C'u^2\,Sb'''$, with 41·8 lead, 12·9 copper, 26 antimony, and 19·3 sulphur. Analyses.

Fig. 251.



	Lead.	Copper.	Iron.	Antimony.	Sulphur.	Total.	
1	42·62	12·80	1·20	24·23	17·00	97·85	Hatchett, Endellion.
2	41·66	13·33	...	25·00	20·00	99·99	Smithson.
3	39·00	13·50	1·00	28·50	16·00	98·00	Klaproth, Nanslo, Cornwall.
4	40·84	12·65	...	26·28	20·31	100·08	H. Rose, Neudorf, Harz.
5	41·38	12·68	...	25·68	19·63	99·37	Sinding, Do.
6	38·9	12·3	...	29·4	19·4	100	Dufrénoy, Alais.
7	40·2	13·3	...	28·3	17·8	99·6	Do. Mexico.

It occurs in veins in the crystalline schists and transition rocks along with quartz, galena, and various ores. The finest crystals are found in the Meiseberg near Neudorf in the Harz. It also occurs at Wolfsberg, Clausthal, and Andreasberg, at Braunsdorf in Saxony, Ober-Lahr in Sayn-Altenkirchen, Kapnik in Siebenburg (where it forms the peculiar macles named *Radelerz* or Cog-wheel-ore), Servoz in Savoy, Alais and Pontgibaud in France, in Mexico, and Peru. It was originally discovered in Endellion parish near Redruth in Cornwall by Count Bournon, who named it *Endellionite*; and is also found at Beeralston in Devonshire.

458. WÖLCHITE, *Haidinger;* Antimonkupferglanz, *Breithaupt;* Prismatoidal Copper Glance, *Phillips;* Prismatoidal Dystome Glance, *Mohs.*

Rhombic; but dimensions unknown. The crystals are short rhombic prisms, with the basis and a dome. It also occurs massive. Cleavage, brachydiagonal rather distinct. Fracture imperfect conchoidal. Brittle; H. = 3; G. = 5·7 — 5·8. Colour blackish lead-grey. In the closed tube forms a sublimate of sulphur and sulphuret of arsenic, and fuses to a reddish-brown slag. B.B. on charcoal fuses with effervescence to a lead-grey metallic grain, which, roasted with soda, gives a grain of copper, colouring the support first white, then yellow. Schrötter found 29·90 lead, 17·35 copper, 1·40 iron, 16·65 antimony, 6·04 arsenic, and 28·60 sulphur (= 99·94).

Rammelsberg remarks that this analysis does not lead to any formula, the sulphur being in excess for the metals which only require 25·23 per cent. It occurs in the iron mines at Wölch, or St Gertraud, in the Lavant valley in Carinthia.

459. FREIESLEBENITE, *Haidinger;* Sulphuret of Silver and Antimony, *Phillips;* Schilfglaserz, *Freiesleben;* Peritomous Antimony-Glance, *Mohs.*

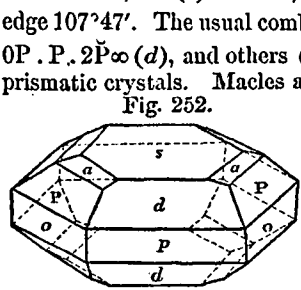
Rhombic; ∞P 100°, $\breve{P}\infty$ 130° 8′. The crystals present rather complex combinations of various prisms and brachydomes. The prisms generally predominate, and often show curved reed-like faces, marked with strong vertical striæ. The macles intersect partly at right angles, partly obliquely, like those of staurolite. It also occurs massive and disseminated. Cleavage, prismatic along ∞P perfect. Fracture conchoidal or uneven. Rather brittle. H.=2 — 2·5; G.=6 — 6·4. Colour steel-grey inclining to dark lead-grey; streak the same. B.B. on charcoal evolves sulphurous acid, deposits antimony and lead on the support, and leaves a grain of silver, which, with borax, sometimes shows reaction for copper. Chem. com. $^{A'g3}\,Sb''' + P'b^{3}\,Sb'''$, with

22·5 silver, 32·4 lead, 26·8 antimony, and 18·3 sulphur, part of the lead sometimes replaced by copper. Wöhler found 22·93 silver, 30·27 lead, 27·38 antimony, and 18·74 sulphur (= 99·32) as the mean of several analyses, one of which gave also 0·11 iron and 1·22 copper. This mineral is rare, and occurs chiefly in veins in gneiss, at the Himmelsfürst and other mines near Freiberg in Saxony, where it is associated with galena, zinc-blende, antimonite, quartz, calc-spar, and other minerals. It is also said to occur at Kapnik in Siebenburg, and Ratiborschitz in Bohemia; at the latter, according to Zincken, containing bismuth.

460. STEPHANITE, *Haidinger;* Brittle Sulphuret of Silver, *Phillips;* Brittle Silver ore, *Allan;* Sprödglaserz, *Werner;* Argent antimonié sulfuré noir, *Hauy;* Prismatic Melane-Glance, *Mohs.*

Rhombic; ∞P (*o*) 115° 39′, P with middle edge 104° 19′, 2P̆∞ middle edge 107°47′. The usual combinations are 0P (*s*) . ∞P (*o*) . ∞P̆∞ (*p*), 0P . P . 2P̆∞ (*d*), and others (fig. 252), forming thick tabular or short prismatic crystals. Macles are frequent, united by a face of ∞P, and generally repeated three or four times.

Fig. 252.



It also occurs massive, disseminated, and in various forms. Cleavage, domatic along 2P̆∞ and brachydiagonal, but both imperfect. Fracture conchoidal or uneven. Sectile. H. = 2 — 2·5; G. = 6·2 — 6·3. Colour iron-black to blackish lead-grey, rarely with an iridescent tarnish. Fuses in the open tube, and yields a sublimate of antimony oxide and arsenious acid. B.B. on charcoal forms, with a weak odour of arsenic, a dark grey metallic globule, which in the reducing flame (especially with soda), yields a grain of silver. Easily decomposed in warm nitric acid, leaving antimony oxide and sulphur. Chem. com. $A'^{g6}\,Sb'''$, with 70·4 silver, 14 antimony, and 15·6 sulphur, but the silver partly replaced by iron or copper, the antimony by arsenic. Analyses.

	Silver.	Iron.	Copper.	Arsenic.	Antimony.	Sulphur.	Vein-stone.	Total.	
			0·5						
1	66·5	5·0			10·0	12·0	1·0	95·0	Klaproth, Freiberg.
2	65·50	5·46	3·75	3·30	...	19·40	1·00	98·41	Brandes, Do.
3	68·54	...	0·64	...	14·63	16·42	...	100·23	H. Rose, Schemnitz.

It has chiefly been found in Saxony at Freiberg, Schneeberg, Johann-Georgenstadt, and Annaberg; in Bohemia, at Joachimsthal and

Przibram; in Hungary at Schemnitz; rarely at Andreasberg in the Harz, and in many parts of Mexico, in Peru and Siberia. It has also been found massive and pulverulent at Wheal Duchy and Herland in Cornwall. It occurs in veins in crystalline, transition, and trachyte rocks, with arsenic, silver, and other ores, along with quartz, calc-spar, fluor spar, and heavy spar. It is a valuable ore of silver.

461. POLYBASITE, *Rose*, *Phillips;* Eugenglanz, *Breithaupt;* Rhombohedral Melane-Glance, *Mohs.*

Hexagonal; P 117° 0′. The usual combinations are 0P . ∞P and 0P . P; the crystals always tabular, and often very thin. It also occurs massive and disseminated. Cleavage, basal imperfect. Sectile, and easily frangible. H. = 2 — 2·5; G. = 6·0 — 6·25. Colour and streak iron-black. B.B. decrepitates slightly and fuses very easily; in the open tube yields sulphurous acid and a white sublimate; and on charcoal a coating of antimony oxide. With fluxes shows reaction for copper; and with soda gives a grain of cupriferous silver. With acids acts like bournonite. Chem. com. $(A'_g, C'_u)^9 (Sb''', As''')$, but L. Gmelin says the copper occurs as C'_u. Analyses.

	Silver.	Copper.	Iron.	Zinc.	Arsenic.	Antimony.	Sulphur.	Total.	
1	64·29	9·93	0·06	...	3·74	5·09	17·04	100·15	H. Rose, Guarisamey.
2	72·43	3·04	0·33	0·59	6·23	0·25	16·83	99·70	Do. Schemnitz.
3	69·99	4·11	0·29	...	1·17	8·39	16·35	100·30	Do. Freiberg.

Polybasite occurs in veins in the crystalline or transition strata, and in trachyte with stephanite, from which it was distinguished by G. and H. Rose. It is found in many mines near Freiberg in Saxony, at Joachimsthal in Bohemia, Schemnitz in Hungary, and Guanaxuato and Guarisamey in Durango, Mexico; and is used as an ore of silver.

462. STERNBERGITE, *Haidinger*, *Phillips;* Prismatic Eutome-Glance, *Mohs.*

Rhombic; P with middle edge 118° 0′, transverse section 119° 30′. The crystals are usually thin tabular, from 0P, bounded on the sides by P, $2\breve{P}\infty$, or other forms, and occur in macles united by a face of ∞P, or in fan-shaped, scopiform, and spheroidal groups. It is also found massive, with a flat columnar structure. Cleavage, basal very perfect. Sectile and flexible in thin laminæ. H. = 1 — 1·5; G. = 4·2 — 4·25. Colour dark pinchbeck-brown, often with a violet-blue tarnish. Streak black. B.B. on charcoal emits odour of sulphur, and fuses to a magnetic globule covered with silver. With borax

forms a glass coloured by iron, and a grain of silver. It is decomposed by nitrochloric acid, with residue of sulphur and chloride of silver. Zippe, in a variety from Joachimsthal, found 33·2 silver, 36 iron, and 30 sulphur (= 99·2); or very nearly 1 atom silver, 4 atoms iron, and 6 atoms sulphur, from which no formula can be deduced. Berzelius proposes $\dot{A}g + 2\dot{F}e'''$, with 32·7 silver, 33·6 iron, and 33·7 sulphur. In a variety from Schneeberg, Plattner found with the blowpipe 29·7 per cent. silver. It also occurs at Johann-Georgenstadt in Saxony.

The *Flexible Sulphuret of Silver* of Bournon is probably identical with sternbergite. Its very small crystals are, however, said to be monoclinohedric (C = 55°), and appear like rhomboidal tables formed of ($\infty P\infty$), bounded on the sides by other forms. It has a very perfect clinodiagonal cleavage, is very soft, flexible in thin plates, and of a blackish colour with dull metallic lustre. It occurs in Hungary, and at Freiberg; and, according to Wollaston, consists of silver, sulphur, and iron.

463. STANNINE, *Beudant;* Sulphuret of Tin, *Phillips;* Tin-pyrites, *Allan;* Zinnkies, *Werner;* Etain sulfuré, *Hauy;* Hexahedral Dystome-glance, *Mohs.*

Tesseral. The hexahedral crystals are very rare, and generally it occurs massive, granular, and disseminated. Cleavage, hexahedral very imperfect. Fracture uneven or small conchoidal. Brittle. H. = 4; G. = 4·3 — 4·5. Colour steel-grey, sometimes inclining to brass-yellow (from copper pyrites). Streak black. In the open tube evolves white fumes and sulphurous acid. B.B. on charcoal fuses in a strong heat, becomes white on the surface, and forms close round the assay a white coating of peroxide of tin, which is not volatile. After roasting shows reaction for copper and iron, and, fused with soda and borax, leaves a pale, imperfectly malleable grain of copper. Easily decomposed by nitric acid, leaving tin peroxide and sulphur. The solution is blue. Chem. com. $\dot{C}u^2\,Sn'' + (\dot{F}e, \dot{Z}n)^2\,Sn''$. Analyses.

	Sulphur.	Tin.	Copper.	Iron.	Zinc.	Lead.	Vein-stone.	Total.	
1	30·5	26·5	30·0	12·0	...	...	...	99·0	Klaproth, Wheal Rock.
2	29·64	25 55	29·39	12·44	1·77	...	1·02	99 81	Kudernatsch, *Do.*
3	29·93	31·62	23·55	4 79	10·11	...	...	100	Johnston, St Michael's Mount.
4	29·89	28·94	26·31	6·80	6·93	0·41	...	99·28	Rammelsberg, Zinnwald.

Stannine occurs chiefly at Wheal Rock near St Agnes in Cornwall, where it forms a considerable vein, accompanied by pyrites and

blende; and recently at Carn Brea, where it is sold as an ore of copper. The composition of No. 3 is peculiar, but the metals found would require 31·18 sulphur. At Zinnwald in the Erzgebirge, the only known locality out of Cornwall, it is associated with blende and galena, the lead being a mixture of the latter, and has G. = 4·506. The Cornish miners often name it Bell-metal ore. Some crystals from St Agnes are said to belong to the rhombic system.

464. CUPREOUS BISMUTH, *Phillips;* Kupferwismutherz, *Klaproth;* Bismuth-Copper ore, *Mohs.*

Rhombic probably; occurs massive and disseminated; occasionally in columnar aggregates apparently of rhombic prisms. Cleavage, distinct along a vertical plane. Fracture uneven and fine granular. Sectile. H. = 8·5; G. = 5. Colour steel-grey, with a light lead-grey tarnish. Streak black. In the open tube yields sulphur and a white sublimate. B.B. on charcoal fuses very readily, frothes, and stains the support yellow; with soda gives a grain of copper. Soluble in nitric acid, with residue of sulphur; the solution, if not too acid, forms a white precipitate with water. Klaproth found 34·66 copper, 47·24 bismuth, and 12·58 sulphur (= 94·48), and conjectured the loss to be oxygen. It was formerly found in cobalt veins in granite near Wittichen in the Schwarzwald; and in six-sided prisms at Wheal Buller in Cornwall.

465. BISMUTHIC SILVER, *Phillips;* Wismuthbleierz, *Hausmann;* Silver-Bismuth-Ore, *Mohs.*

Crystallization unknown. Only found in delicate acicular or capillary crystals; or massive and disseminated. Sectile and soft. Colour pale lead grey, with darker tarnish. B.B. fuses easily, forms a large deposit on the charcoal, and evolves sulphurous acid. Soluble in nitric acid. Klaproth found 33 lead, 27 bismuth, 15 silver, 4·3 iron, 0·9 copper, and 16·3 sulphur (96·5).

The specimen was from a vein in gneiss in the Schapbach valley in Baden, where it was wrought as an ore of silver and lead.

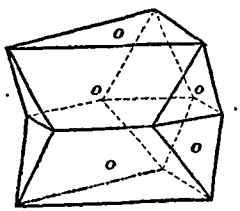
V. FAMILY.—BLENDES.

466. BLENDE, *Werner, Allan;* Sulphuret of Zinc, *Phillips;* Zinc-blende, *Jameson;* Dodecahedral Garnet-Blende, *Mohs.*

Tesseral and tetrahedral semitesseral; the most common forms are $\frac{O}{2}$, $-\frac{O}{2}$, (sometimes formed as O), ∞O, $-\frac{O}{2}$, $\infty O \infty$, and others.

The combinations are very numerous; and macles remarkably common, united by a face of O, fig. 253, and fig. 78, p. 41 above. They are generally several times repeated, and the crystals so contracted as to appear much distorted. Frequently it occurs massive and granular, rarely radiating and very fine fibrous, and then reniform or botryoidal, and partly with a curved lamellar structure. Cleavage dodecahedral along ∞O, very perfect. Very brittle; H. = 3·5 — 4; G. = 3·9 — 4·2. Semitransparent to opaque. Lustre adamantine and resinous. Colour commonly brown or black, also red, yellow, and green. It is a very weak or non-conductor of electricity. B.B. generally decrepitates and often violently, but changes little, only fusing on very thin edges. In the oxidating flame in a strong heat deposits zinc oxide on the charcoal, which appears yellow when hot, but becomes paler when cold. Soluble in concentrated nitric acid, leaving sulphur. Chem. com. z'n with 66·8 zinc and 33·2 sulphur, but generally part of the zinc replaced by iron or cadmium. Analyses.

Fig. 253.



	Sulphur.	Zinc.	Iron.	Cadmium.	Vein-stone.	Total.	
1	32·63	66·63	0·74	...	...	100	Thomson.
2	33·66	66·34	...	...	...	100	Arfvedson.
3	33·6	63·0	3·4	...	...	100	Berthier, Bagnères de Luchon.
4	36·2	55·0	8·6	...	...	99·8	Lecanu, Chéronies.
5	2·6	45·0	15·7	...	11·4	100·7	Boussingault, Marmato.
6	33·0	61·5	4·0	...	1·5	100·0	Berthier, England.
7	33·15	61·40	2·29	1·50	...	98·34	Löwe, Przibram.
8	32·75	62·62	2·20	1·78	...	99·35	Do. Do.
9	32·10	64·22	1·32	trace	0·72*a*	99·16	Kersten, Raibl, Carinthia.
10	33·73	53·17	11·79	...	0·74*b*	99·43	Scheerer, Christiana.

(*a*) = antimony and lead oxide, + 0·80 water; (*b*) manganese.

The variety from Candado (No. 5), gives 77·5 sulphuret of zinc and 22·5 sulphuret of iron, and another from Salto, also near Marmato in Popayan, gave 76·8 of the former to 23·2 of the latter. This is very nearly 3 atoms to 1 atom, and Boussingault considers it a distinct combination, which he names *Marmatite;* but the other analyses show that the iron only replaces part of the zinc. The yellow varieties are generally the purest, and have the highest specific gravity, = 4·107 — 4·111, *Breithaupt;* whilst the brown with most iron have G. = 4·076 — 3·945, *Breit.* The latter are also easily known by the powder or small fragments after a short exposure B.B. on charcoal being attracted by the magnet. Gold is said to occur in some

blendes. The yellow foliated variety phosphoresces at a high temperature.

This is a very common ore in many countries, and in various formations. Dark coloured crystalline varieties occur in Derbyshire, Cumberland, and Cornwall, where some from near St Austle contain cadmium. The most remarkable other localities in Europe are,—for the green and yellow blendes, Przibram, Schemnitz, and Kapnik; the brown foliated, Freiberg, Schwarzenberg, Lautenthal, and Nagyag; black blende, Freiberg, Zellerfeld, Kremnitz, and Schemnitz; the radiated brown blende, Przibram and Kapnik; the fibrous at Raibl, Freiberg, and Aix la Chapelle. In North America it is abundant, and fine brilliant yellow crystals occur in limestone at Lockport and Goat Island near Niagara. The black blende of Shelburne, N. H. is occasionally crystallized, and contains cadmium (3 per cent.) Very fine specimens are also found in Peru and Chili.

This mineral has been used as an ore of zinc, but both in Cornwall and the Harz with very little success; and it has also been attempted to produce the white or zinc vitriol and sulphuric acid from it in the latter place, and even to grind it up as a pigment. It is often highly prejudicial to the mechanical preparation of other ores; and also to their reduction by smelting.

467. VOLTZINE, *Fournet*, *Mohs.*

Occurs in small hemispherical incrustations, with a thin, curved-lamellar structure. Fracture conchoidal. H. = 4·5; G. = 3·66. Colour brick-red inclining to yellow or brown. Opaque or semi-translucent. Lustre vitreo-resinous on the fractured surfaces, pearly on the divisional planes. B.B. acts like zinc-blende. Soluble in hydrochloric acid with evolution of sulphuretted hydrogen. Chem. com. $4\dot{Z}n_n + \dot{Z}n$. Fournet's analysis gave 82·92 sulphuret of zinc, 15·34 oxide of zinc, and 1·84 iron peroxide (= 100·10), and also a little of some resinous substance. It is found in a quartz vein at Rozières near Pontgibaud in Auvergne. It agrees in composition with some slags from Freiberg, and Altenberg near Aachen, examined by Kersten.

468. ALABANDINE, *Del Rio*, *Beudant;* Sulphuret of Manganese, *Phillips;* Manganblende, *Blumenbach;* Manganèse sulfuré, *Hauy;* Hexahedral Glance-Blende, *Mohs.*

Tesseral; O and ∞O∞; but usually massive, granular, and disseminated. Cleavage, hexahedral perfect. Fracture uneven, rather brittle. H. = 3·5 — 4; G. = 3·9 — 4. Opaque; lustre semimetallic, duller when tarnished; colour iron-black to dark steel-grey, with a brownish-black tarnish; streak dark green. In the closed

tube is unchanged, in the open tube becomes greyish-green. B.B. on charcoal, after long roasting in the reducing flame, fuses with great difficulty to a brown slag. With borax gives reaction for manganese; and is dissolved by salt of phosphorus evolving much inflammable gas. Soluble in hydrochloric acid, giving out sulphuretted hydrogen. Chem. com. M'_n, with 63·6 manganese and 36·4 sulphur; or, by Arfvedson's analysis of a specimen from Siebenburg, 62·1 manganese and 37·9 sulphur (= 100).

Klaproth found 82 protoxide of manganese, 11 sulphur, and 5 carbon (= 98); and Del Rio 54·5 manganese, 39 sulphur, and 6·5 silica (=100), in a variety from Mexico,—both differing much from the formula. It is found in veins with foliated tellurium, blende, and quartz at Nagyag and Kapnik in Siebenburg; in Mexico, and in quartz veins in Minas Geraes in Brazil.

469. HAUERITE, *Haidinger.*

Tesseral; O, $\infty O\infty$, and ∞O; also $O \cdot \infty O\infty$, sometimes with other faces. The crystals occur either single or in spherical groups. Cleavage, hexahedral perfect. H. = 4; G. = 3·463. Semitranslucent on very thin edges; lustre metallic-adamantine; colour reddish-brown to brownish-black; streak brownish-red. In the closed tube yields sulphur, and leaves a green mass, which B.B. becomes brown on the surface, and is soluble in hydrochloric acid. With fluxes acts like alabandine. Chem. com. Mn'', with 46·28 manganese and 53·72 sulphur. Patera found 42·97 manganese, 53·64 sulphur, 1·30 iron, and 1·20 silica (= 99·11), which, subtracting the silica and the iron as a bisulphuret, gives 45·2 manganese and 54·8 sulphur. It is found in clay with gypsum at Kalinka near Altsohl in Hungary.

470. GREENOCKITE, *Brooke* and *Connel.*

Hexagonal, and probably hemimorphic; P 87° 13′, 2P 124° 34′. The usual combinations are $2P \cdot 0P \cdot \infty P \cdot P$, or $P \cdot 2P \cdot \infty P$. Only the upper half of the crystals is formed, and they are attached singly. Cleavage, prismatic along ∞P imperfect, basal perfect. H. = 3 — 3·5; G. = 4·8 — 4·9. Translucent; lustre brilliant resinous, or adamantine; colour honey or orange-yellow, rarely brown; streak yellow. B.B. decrepitates and becomes carmine-red, but again yellow when cold. Fused with soda, it forms a reddish-brown coating on charcoal. Soluble in hydrochloric acid, evolving sulphuretted hydrogen. Chem. com. Cd', or, by Thomson's analysis, 77·6 cadmium and 22·4 sulphur. Connel found 77·30 cadmium and 22·56 sulphur (= 99·86). It occurs in a porphyritic amygdaloid near Bishoptown in Renfrewshire, and is named from Lord Greenock, its discoverer.

VI. Family.—Ruby-Blende.

471. Pyrargyrite, *Glocker;* Red Silver, *Jameson, Phillips;* Rothgiltigerz, *Werner;* Argent antimonié sulfuré, *Hauy;* Rhombohedral Ruby-Blende, *Mohs.*

Rhombohedric; R 108° 18′ (*Mohs*); the other most important forms are, $-\frac{1}{2}R$, 0R, $-2R$ (*r*), R^3, $\infty P2$ (*s*), and ∞R (*l*). The latter is generally formed as a trigonal prism, and the combinations, sometimes very complex, are also occasionally hemimorphic. The crystals are generally prismatic (figs. 254, 255); but in the arsenical variety

Fig. 254.

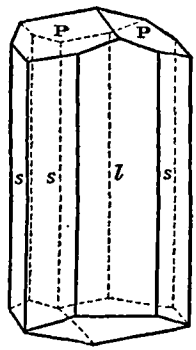
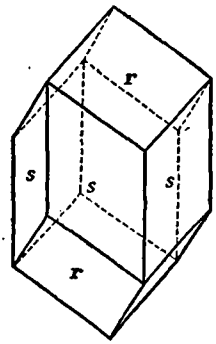


Fig. 255.



the scalenohedron R^3 often prevails. Macles are common of various kinds, but most frequently with the twin axis a polar edge of $-\frac{1}{2}R$. It also occurs massive, disseminated, dendritic, or investing. Cleavage, rhombohedric along R rather perfect. Fracture conchoidal to uneven and splintery. Slightly sectile, sometimes almost brittle. H. = 2 — 2·5.

In this species, two varieties may be distinguished by the following characters:—

Dark Pyrargyrite, or Antimonial Silver-Blende, *Naumann.*	Light Pyrargyrite, or Arsenical Silver-Blende, *Naumann.*
R = 108° 39′ 39″, *Breit.*	R = 107° 48′ 39″, *Breit.*
G. = 5·75 — 5·85.	G. = 5·5 — 5·6.
Crimson-red to blackish lead-grey.	Cochineal to crimson-red.
Streak cochineal to cherry-red.	Streak aurora-red to cochineal-red.
Translucent on the edges to opaque.	Semitransparent to translucent on the edges.
Chem. com. essentially A'_3S^3Sb''' = 59 silver, 23·5 antimony, and 17·5 sulphur.	Chem. com. essentially A'_3S^3As''' = 65·4 silver, 15·1 arsenic, and 19·4 sulphur.

B.B. on charcoal fuses easily, gives out sulphurous acid and antimony fumes, and leaves a grain of silver. Soluble in nitric acid, leaving sulphur and antimony protoxide. Solution of potash extracts sulphuret of antimony. Analyses, Nos. 1, 2, 3.

B.B. on charcoal fuses easily, gives out sulphurous acid and arsenical odour, and leaves a brittle metallic grain difficultly reduced to pure silver. Soluble in nitric acid, with remainder of sulphur and arsenious acid. Solution of potash extracts sulphuret of arsenic. Analysis, No. 4.

	Silver	Antimony.	Arsenic.	Sulphur.	Earthy mixture	Total.	
1	58·95	22·85	...	16·61	0·30	98·71	Bonsdorff, Andreasberg.
2	60·2	21·8	...	18·0	...	100	Wöhler, Mexico.
3	57·45	24·59	...	17·76	...	99·80	Böttger, Zacatecas.
4	64·67	0·69	15·09	19·51	...	99·96	H. Rose, Joachimsthal.

The difference of the two varieties in angular dimensions still requires confirmation, and Zincken states that the light pyrargyrite from Andreasberg contains no arsenic.

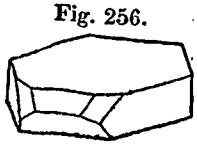
Andreasberg is one of the chief localities of the dark red varieties, whilst the pale is rare. In Saxony, the former is common near Freiberg; the latter at Johann-Georgenstadt, Annaberg, Schneeberg, and Marienberg. In Bohemia the light red occurs chiefly at Joachimsthal (a specimen from which, weighing above six pounds, and with crystals several inches long, is in the Prague Museum); the dark at Przibram, and other mines. This variety also occurs at Schemnitz and Kremnitz in Hungary. Markirchen in Alsace, Kongsberg in Norway, and many of the Mexican mines are other localities. Pyrargyrite has been found at Wheal Brothers, and with native silver at Wheal Duchy in Cornwall.

This is a very valuable ore of silver. It resembles red orpiment, but the latter has a lower specific gravity and yellow streak. From cinnabar it is distinguished by not volatilizing before the blowpipe.

472. MIARGYRITE, *H. Rose*, *Phillips*; Hemiprismatic Ruby-Blende, *Mohs.*

Monoclinohedric; C = 81° 36′, P 90° 53′, —P 95° 59′, and other partial forms. The rather complex combinations have a very peculiar, pyramidal, short prismatic, or tabular aspect (fig. 256). The crystals are attached singly or form small groups; and it also occurs massive and disseminated. Cleavage, indistinct traces in several directions. Fracture imperfect conchoidal or uneven. Sectile. H. = 2 — 2·5; G. = 5·3 — 5·4. Opaque; or in thin splinters dark blood-red, translucent.

Fig. 256.



Lustre metallic-adamantine. Colour blackish lead-grey, inclining to iron-black and steel-grey. Streak cherry-red. In the open tube fuses readily, yields sulphurous acid, and a sublimate of antimony oxide. B.B. with soda on charcoal leaves a grain of silver. With acids and solution of potash acts like the dark pyrargyrite. Chem. com. $A'g\,Sb'''$, with 35·9 silver, 42·9 antimony, and 21 2 sulphur; or, by H. Rose's analysis, 36·40 silver, 1·06 copper, 0·62 iron, 39·14 antimony, and 21·95 sulphur (= 99·17). The specimen was from a mine at Bräunsdorf near Freiberg, where only this rare ore is known.

Hausmann considers the *Fahle Rothgiltigerz* from Andreasberg as a miargyrite, with part of the antimony replaced by arsenic. It melts even in the flame of a candle, and is one of the richer silver ores. The *Hypargyronblende* of Breithaupt, from Clausthal, is probably the same mineral. Plattner found in it 35 per cent. silver, with much arsenic and sulphur, some iron, and a little antimony.

473. XANTHOKON, *Breithaupt, &c.*

Rhombohedric; 0R . R and 0R . R . —2R. The inclination of R : 0R is 110° 30′, of —2R : 0R 100° 35′. The crystals appear as very thin hexagonal tables, with alternating oblique side faces. It also occurs in small reniform masses, with a crystalline granular structure. Cleavage, rhombohedric along R and basal, both more or less perfect. Rather brittle, and very easily frangible. H. = 2 — 2·5; G. = 5·0 — 5·2. Translucent and transparent; lustre adamantine. Colour orange-yellow or yellowish-brown; streak slightly darker. In the closed tube fuses very easily, becomes lead-grey, and yields a small sublimate of sulphuret of arsenic. In the open tube gives out sulphurous and arsenious acid. B.B. on charcoal evolves fumes of sulphur and arsenic, and leaves a grain of silver. Chem. com. $A'g^3\,As''' + A'g^3\,As'''$, with 63·4 silver, 14·7 arsenic, and 21·9 sulphur. Analyses.

	Silver.	Iron.	Arsenic.	Sulphur.	Total.	
1	64·18	0·97	13·49	21 36	100	Plattner (brown var.)
2	63·88	...	14·32	21·80	100	Do. (yellow var.)

This mineral is thus a compound of the light pyrargyrite with an analogous sulpho-arsenite; and, according to Rammelsberg, the first instance of a double salt of sulphur with two acids. It occurs in the Himmelsfürst mine at Freiberg.

The *Feuerblende* of Breithaupt, in very delicate crystals, like those of stilbite, generally in scopiform groups, and with one perfect cleav-

age, is probably identical. It is sectile and slightly flexible. H. = 2; G. = 4·2 — 4·3. Translucent, pearly adamatine, and hyacinth-red. B.B. acts like pyrargyrite; and, according to Zincken, contains sulphur, antimony, and silver (= 62·3 per cent., *Plattner*). It is found in the Kurprinz mine at Freiberg, and at Andreasberg.

474. CINNABAR, *Jameson*, *Allan*; Sulphuret of Mercury, *Phillips*; Zinnober, *Werner*; Mercurblende, *Naumann*; Mercure sulfuré, *Hauy*; Cinabre, *Beudant*; Peritomous Ruby-blende, *Mohs*.

Rhombohedric; R 71° 47′. Common forms, 0R, ½R, ⅓R, ∞R. The crystals appear rhombohedric or thick tabular; they are chiefly small and conjoined in druses. It also occurs disseminated and granular, compact, or earthy. Cleavage, prismatic along ∞R rather perfect. Fracture uneven and splintery. Sectile. H. = 2 — 2·5; G. = 8 — 8·2. Semitransparent or opaque. Lustre adamantine. Cochineal-red, with a lead-grey and scarlet-red tarnish. Streak scarlet-red. In the closed tube it entirely sublimes; in the open tube sublimes, partly without decomposition, partly as metallic mercury, whilst sulphurous acid escapes. In the closed tube with soda it yields only mercury. Perfectly soluble in nitrochloric acid, but not in hydrochloric acid, nitric acid, or solution of potash. Chem. com. HgS, with 86·2 mercury and 13·8 sulphur. In a variety from Japan, Klaproth found 84·50 mercury and 14·75 sulphur (= 99·25). In another from Neumärtel in Carniola, 85·00 mercury, and 14·25 sulphur (= 99·25).

Cinnabar occurs in the crystalline, transition, and secondary strata, in beds or veins, with native mercury, iron pyrites, and other ores. Its chief localities are Idria in Carniola, and Almaden and Almadenejos in Spain, where Pliny says it was wrought under the name of *Minium*. Fine crystals are found in the coal formation at Wolfstein and Moschellandsberg in Rhenish Bavaria. It also occurs at Hartenstein in Saxony; near Clausthal in the Harz; in several places in Carinthia; Eisenerz in Styria; Hörzowitz in Bohemia; Schemnitz, Kremnitz, Szlana, and Rosenau in Hungary; Ripa in Tuscany; in Siebenburg, in the Ural and Altai; in China and Japan; and in considerable abundance in California, Mexico, and Peru.

This mineral is the principal ore of mercury, obtained either by sublimation or distillation. The purer varieties are used as a pigment.

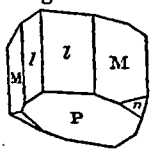
The *fibrous cinnabar* seems merely a mixture with marcasite. The *Hepatic cinnabar* of Phillips, or *Lebererz* of Werner, is also an intimate mixture with idrialite, carbon, and earthy matter. Its colour

is dark cochineal-red or lead-grey, and almost iron black. Streak red. G. = 6·8 — 7·3. It occurs at Idria, partly compact, partly curved lamellar (*Korallenerz*); the latter sometimes described as a petrifaction. Klaproth found in it 81·80 mercury, 13·75 sulphur, 2·30 carbon, 0·65 silica, 0·55 alumina, 0·20 iron peroxide, 0·02 copper (= 99·27); or, according to Schrötter's estimate, 94·8 sulphuret of mercury, 2·5 idrialin, and 0·3 sulphuret of iron.

475. REALGAR, *Phillips;* Red Orpiment, *Jameson, Allan;* Rothes Rauschgelb, *Werner;* Arsenic sulfuré rouge, *Hauy;* Hemiprismatic Sulphur, *Mohs.*

Monoclinohedric; C = 66° 44′ (*P*), ∞P (*M*) 74° 23,′ (P∞) (*n*) 132°, ∞P2 (*l*) 113° 20′. The crystals are short or long prismatic (fig. 257), and attached singly or in druses. It also occurs massive, disseminated, and investing. Cleavage, basal and clinodiagonal, rather perfect, prismatic imperfect. Fracture small conchoidal to uneven or splintery. Sectile; H. = 1·5 — 2; G. = 3·4 — 3·6. Semitransparent or opaque. Lustre resinous. Colour aurora-red; streak orange-yellow. Becomes negative electric by friction. In the closed tube it sublimes as a dark yellow or red mass; in the open tube volatilizes with a deposit of arsenious acid. B.B. on charcoal fuses and burns with a yellowish-white flame. Acids act on it with difficulty. In warm solution of potash it changes into a black powder. Chem. com. As'', with 70 arsenic and 30 sulphur. Klaproth found in a specimen from the Bannat 68 arsenic and 30·5 sulphur (= 98·5). Laugier 69·57 arsenic and 30·43 sulphur (= 100).

Fig. 257.

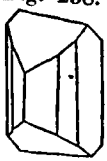


This mineral seems the Sandaracha of Dioscorides and Pliny It occurs in veins in rocks of various age. Fine crystals are obtained at Kapnik and Nagyag in Siebenburg, and at Felsobanya and Tajowa in Hungary; less beautiful varieties at Andreasberg and Wolfsberg in the Harz; and in the dolomite of St Gotthardt. Minute but well-formed crystals occur on Vesuvius and the Solfatara. The artificial preparation is used as a pigment.

476. ORPIMENT, *Phillips;* Auripigmentum, *Pliny;* Gelbes Rauschgelb, *Werner;* Arsenic sulfuré jaune, *Hauy;* Prismatoidal Sulphur, *Mohs.*

Rhombic; ∞P 117° 49′, P̄∞ 83° 37′. The crystals usually short prismatic (fig. 258), occur in irregular masses or in druses. It is also found reniform, but most frequently disseminated in columnar or granular foliated masses. Cleavage brachydiagonal, very perfect;

Fig. 258.



the planes striated vertically. Sectile, and in thin laminæ flexible; H. = 1·5 — 2; G. = 3·4 — 3·5. Semitransparent or opaque; lustre resinous or pearly on the cleavage planes. Colour citron-yellow to orange-yellow. Becomes negative electric by friction. In the closed tube yields a dark-yellow or red sublimate; in the open tube burns and deposits arsenious acid. Fused with soda it yields metallic arsenic. Soluble in nitrochloric acid, in potash, and in ammonia. Chem. com. As''', with 61 arsenic and 39 sulphur. Klaproth found 62 arsenic and 38 sulphur; Laugier 61·86 arsenic, and 38·14 sulphur.

This mineral occurs usually imbedded in clay along with realgar. Its more important localities are Tajowa near Neusohl in Hungary, various parts of Servia, Wallachia, Natolia, and Siebenburg; at Hall in Tyrol, in granular gypsum; in veins at Felsobanya, Kapnik, and Andreasberg; in the dolomite of St Gotthardt; at Braons in the Maritime Alps; and at Zimapan in Mexico. In the Solfatara and similar places it seems a product of volcanic sublimation. At Andreasberg it is sometimes produced from the decomposition of ores containing arsenic and sulphur; and also during the roasting of silver ores. The pigment is mostly artificial.

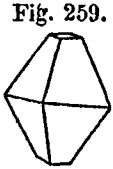
VII. ORDER.—THE INFLAMMABLES.

I. FAMILY.—SULPHUR.

477. SULPHUR, *Phillips;* Schwefel, *Werner;* Soufre, *Hauy;* Prismatic Sulphur, *Mohs.*

Rhombic; P with polar edges 106° 38′, 84° 58′, middle edge 143° 17′; ∞P 101° 58′. Other common forms are 0P, $\frac{1}{3}$P, $\breve{P}\infty$. The crystals are generally pyramidal from predominance of P (fig 259); and they are attached singly or in druses. It also occurs in reniform, spherical, or stalactitic incrustations, or massive, disseminated, or pulverulent. Cleavage, basal and prismatic along ∞P imperfect Fracture conchoidal to uneven or splintery. Rather brittle. H. = 1·5 — 2·5; G. = 1·9 — 2·1. Transparent or translucent on the edges; lustre resinous, or adamantine on the crystal

Fig. 259.



faces; colour sulphur-yellow, passing into honey-yellow, yellowish-brown, and red, or into straw-yellow, yellowish-grey, and white. In the closed tube it sublimes, at 227° Fahr. fuses, and at 518° takes fire, and burns with a blue flame, forming sulphurous acid. Chem. com. sulphur, occasionally more or less mixed with other substances.

Mitscherlich observed that whilst the crystals formed by evaporating a solution of sulphur in sulphuret of carbon were similar to those found in nature, those produced by the slow cooling of fused sulphur were monoclinohedric. But in certain circumstances melted sulphur also forms rhombic pyramids, as is seen in many of the sulphur manufactories in the lower Harz. According to Frankenheim, the formation of one or the other kind of crystals depends on the temperature,—all produced at a temperature above 257° being monoclinohedric, those below this temperature either monoclinohedric or rhombic, but with more probability that they are rhombic the lower the temperature falls. The clinohedric sulphur, when cooled, passes sooner or later into the rhombic. In certain circumstances both forms are deposited from the same solution, which probably contains sulphur in two distinct conditions.

Sulphur occurs especially in gypsum and the connected clays and marls; also in the brown coal and carboniferous formations, and rarely in beds or veins in the transition or crystalline slates. It is very common in the craters of volcanos and solfataras. The finest crystals are obtained at Girgenti and other parts of Sicily along with celestine, and at Conil near Cadiz in Spain. Large masses occur in Poland, Sicily, the Lipari Islands, the Solfatara near Naples, in Iceland and Java. The Sandwich Islands, Peru, and Chili, also furnish fine specimens. It is often deposited from springs, as at Aix la Chapelle, and in small amount from several in the coal formation of Scotland and of other countries. In 1844 nearly 148 million, and in 1845 96 million pounds avoirdupois of sulphur were procured in Sicily, of which Britain received about 40 million pounds.

478. Selen-sulphur, *Stromeyer.*

This mineral, of an orange-yellow or yellowish-brown colour, occurs on Vulcano, one of the Lipari islands, mixed with, or as the colouring matter of sal-ammonia. It fuses readily in the closed tube, and volatilizes. B.B. on charcoal burns, and gives out fumes of selenic and sulphurous acids. According to Stromeyer, it consists of sulphur and selenium, with a trace of arsenic, but is very little known.

Native Selenium, according to Del Rio, occurs at Culebras in Mexico. It is brownish-black or lead-grey, and thin splinters are red translucent. H. = 2; G. = 4·3.

II. Family.—Diamond.

479. **Diamond**; Demant, *Werner;* Diamant, *Hauy;* Octahedral Diamond, *Mohs.*

Tesseral and tetrahedral-semitesseral; $\frac{O}{2}$ and $-\frac{O}{2}$, mostly occurring together and equally formed, ∞O, ∞On, mO, mOn; or the octahedron, rhombic dodecahedron, and hexakisoctahedron, figs. 2, 3, 7, and 5, pp. 8, 9, are the more common forms. The crystals have often curved faces, and more or less approximate to spheres. They occur loose or imbedded singly. Macles are common, united by a plane of O, like fig. 253 p. 497 above, or with parallel systems of axes. Cleavage, octahedral perfect. Fracture conchoidal; brittle. H. = 10; G. = 3·5 — 3·6. Transparent or translucent when dark-coloured. Refracts light strongly, and hence exhibits a fine play of colour. Lustre brilliant adamantine. Colourless, but often coloured in various white, grey, or brown tints, also green, yellow, red, blue, and rarely black. Becomes positive electric by friction. Burns in oxygen gas and forms carbonic acid. Chem. com. pure carbon.

In 1675, Newton, from the optical properties of the diamond, conjectured that it was an unctuous and combustible substance. This was confirmed by the experiments of Lavoisier and others, who found that it could be burnt by the sun's rays concentrated by a lens or mirror. Guyton de Morveau found that with iron it formed steel; and Sir H. Davy proved that it was pure carbon without any mixture of hydrogen. Some, however, incidentally contain other substances, to which they owe their colour. In the ashes of burnt diamonds Petzholdt thought he could perceive traces of vegetable cells; but Wöhler, who examined under the microscope a great number of diamonds containing foreign matter, observed no traces of organic structure. A crystal of a green colour heated before the blowpipe became brown, whilst some brown spots in another were not changed by ignition.

Various opinions have been entertained regarding the origin of diamonds. Jameson conjectured they might be vegetable productions; Brewster thought this opinion confirmed by their optical properties and analogy to amber. Liebig explains their formation by a process resembling putrefaction; and Wöhler asserts that they cannot have been formed in a high temperature, least of all by fusion. Their occurrence in the mica-slate of Brazil, perhaps also in that of the Ural, is not favourable to their immediate vegetable origin.

The chief localities where diamonds have been found are the East Indies and Brazil. In the former they occur in the district between

Pennar, Sonar, and the delta of the Ganges (lat. 14° — 25°); the mines forming five principal groups, or those of Cuddapah, the Pennar, Naudial, Ellora or Golconda, and Sumbhulpur. They are found in a sandstone rock, probably a recent formation. They also occur in Borneo and Malacca. In Brazil they chiefly occur in the district of Serro do Frio in the province of Minas Geraes, in a brown iron-stone, probably of recent origin; but have lately also been discovered in the itacolumite, a variety of quartzose mica-slate. In 1829, and subsequent years, about fifty small diamonds were obtained from the gold sands of the Ural, probably derived from a mica-slate rock like that of Brazil. One or two have also been found in Georgia and North Carolina; and in the Sierra Madre, south-west from Mexico, towards Acapulco.

Among the largest known diamonds are the Pitt or Regent diamond, formerly among the crown jewels of France. In its rough state it weighed 410 carats (each 3·174 grains troy), but now only 136⅜ carats, and has been valued at L.125,000. The diamond in the Russian sceptre weighs 194¾ carats, but is inferior to the former in water. Another, 1 inch 5½ lines long, and 8 lines broad, but only partially polished, was presented by the Persian prince Chosroes to the Russian emperor. The Vienna collection contains a pale-yellow diamond weighing 139½ carats. In Dresden there is one of a peculiar green colour. The largest stones are procured from the East Indies, those found in Brazil rarely exceeding 18 or 20 carats.

Diamonds were first cut by Bergnem of Bruges in 1476. They are the most valuable of precious stones, being estimated at L.8 for one of one carat, and the price increasing as the square of the weight; but this is merely nominal for the larger sizes.

III. Family.—The Coals.

480. Graphite, *Werner, &c.*; Plumbago, *Phillips*; Fer Carburé, ou Graphite, *Haüy*; Rhombohedral Melan-Graphite, *Mohs.*

Hexagonal, but only in thin tabular or short prismatic crystals of 0P . ∞P. Usually it occurs massive, and foliated, radiating, scaly, or compact; also disseminated, or as a constituent of many rocks. Cleavage, basal perfect. Very sectile, flexible in thin laminæ, and sometimes slightly malleable. Feels greasy. H. = 0·5 — 1; G. = 1·9 — 2·2. Opaque; lustre metallic; colour iron-black. Leaves a mark on paper. Is a perfect conductor of electricity. B.B. burns

with much difficulty; in oxygen gas even less easily than the diamond; and heated with nitre in a platina spoon only partially detonates. Chem. com. carbon. Analyses.

	Carbon.	Iron.	Lime and alumina.	Water	Silica.	Total.	
1	53·4	7·9	36·0	2·7	...	100	Prinsep, England
2	71·6	5·0	8·4	...	15·0	100	Do. Himalaya.
3	62·8	...	37·2	...	...	100	Do. Ceylon.
4	81·5	...	18·5	...	...	100	Do. Do. purified.
5	94·0	...	6·0	...	...	100	Do. Do. crystallized.
6	98·9	...	1·2	...	...	100·1	Do. Do. crystallized.

Graphite was long considered a compound of carbon and iron in the proportion of 90·9 to 9·1, which Bertholet found in graphite formed in iron furnaces. Karsten and Sefstrom showed that it was pure carbon, the iron being a mere mixture, and the above analyses prove that it is often wanting. In a variety from Wunsiedel, Fuchs found only 0·33 per cent. ashes. Dumas and Stass observed that graphite, carefully purified still left some sandy colourless grains when burnt; and Erdmann and Marchand also noticed white wooly flakes of silica in the ashes.

Graphite occurs crystallized at Pargas in Finnland, Arendal in Norway, Goldenstein in Moravia, Göpfersgrun in the Fichtelgebirge, Hollette in the Pyrenees, Ticonderoga in New York, in Ceylon, and other places. Griesbach near Hafnerzell in Passau, Marbella in the south of Spain, and the Harz near Elbingerode in eurite porphyry, are other localities. The purest varieties are from Borrowdale in Cumberland. In Scotland, it has been found in gneiss with garnets at Glenstrathfarrer in Inverness-shire, and in the coal formation at Craigman in Ayrshire. At the latter it is evidently common coal altered by contact with trap.

Graphite is used for making pencils, the compact masses being cut into thin slips by means of fine saws. The powder mixed with sulphur and gum was formerly employed for the same purpose; but is now rendered compact simply by pressure in a vacuum. It is also used to form crucibles, which are capable of sustaining intense heat.

The graphite from iron furnaces forms thin hexagonal tables; and hence, as both it and the diamond are pure carbon, this substance must be dimorphous.

481. ANTHRACITE, *Karsten, Phillips, Hauy;* Glance coal, *Jameson*; Glanzkohle, *Werner*; Harzlose Stein-Kohle, Non-bituminous coal, *Mohs.*

Amorphous; massive and disseminated, rarely in columnar forms,

or fibrous and pulverulent. Fracture conchoidal; brittle; H. = 2 — 2·5; G. = 1·4 — 1·7. Opaque; brilliant metallic lustre; colour iron-black or greyish-black. Streak unaltered. Perfect conductor of electricity. Burns difficultly with a very weak or no flame, and does not cake. In the closed tube yields a little moisture, but no empyreumatic oil. Detonates with nitre. Chem. com. carbon, with small proportions of oxygen and hydrogen, and traces of nitrogen; also a mixture of silica, alumina, and peroxide of iron. Analyses in 100 parts.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ashes	
1	90·45	2·43	2·45		4·67	Regnault, Pennsylvania.
2	92·56	3·33	2·53		1·58	Do. Valais.
3	91·98	3·93	3·16		0·94	Do. Mayenne.
4	91.45	4·18	2·12		2·25	Do. Herzogenrath, Aachen.
5	71·49	0·92	1·12		26·47	Do. Macot, Tarentaise.
6	89·77	1·67	3·63	0·36	4·57	Do. Lamure, Isère dpt.
7	90·58	3·60	3·81	0·29	1·72	Jacquelin, Coalbrook, Carmarthenshire.
8	87·22	2·49	1·08	2·31	6·90	Do. Sablé, Sarthe dpt.
9	94·69	1·85	...	2·85	1·90	Do. Vizille, Isère dpt.
10	94·00	1·49	...	0·58	4·00	Do. Isère dept.
11	94·10	2·39	1·34	0·87	1·30	Schafhäutl, Pembrokeshire.
12	85·96	3·16	2·22	trace	7·07*a*	*L. Gmelin*, Offenburg.
13	70·12	3·19	7·59	...	15·47*b*	Kühnert, Meissner.

(*a*) + 1·59 water; (*b*) + 3·63 water volatile at 212°.

There are many other analyses of anthracite. As the gaseous elements, hydrogen, oxygen, and nitrogen increase, this substance approaches nearer to common coal; into which a gradual transition may be traced. The beautiful iridescent colours of some varieties arise from a thin coating of hydrated oxide of iron, and are at once destroyed by hydrochloric acid.

Anthracite seems to be altogether uncrystalline, and in this to differ essentially from graphite. Hauy, however, states that it has a cleavage along the sides of an oblique four-sided prism, and even shows a tendency to form acute four-sided pyramids; and Breithaupt that it has a rhombic crystallization with a basal cleavage. Its original organic nature can scarcely be doubted. It frequently occurs where igneous rocks have intruded on common or brown coal, and then often forms columnar masses with their axes at right angles to the plane of contact. Many varieties also show vegetable structure under the microscope. Other anthracites, like the fibrous masses found in layers sometimes an inch thick in common or brown coal, must have a different origin. Karsten intimates that these may be portions of the original woody fibre from which the oxygen and hydrogen had escaped before the mass was mineralized; or they may have

arisen from plants containing less of these elements than those forming the remainder of the coal. The carbonaceous matter dispersed through the older stratified rocks, like that in the clayslates, and greywackés of the south of Scotland, is generally changed into anthracite. It is often found in trap or other igneous formations, as in the claystone porphyry of the Calton Hill at Edinburgh. It also occurs in beds of magnetite in the crystalline slates; in hæmatite in the transition rocks; and in clays as at Frankenberg in Hessia, either alone in nests, or along with copper and silver ores. It also forms veins either alone or with other minerals, as the graphite-like variety mixed with the silver ores at Kongsberg, Norway.

Anthracite is very common in many parts of the English, Scottish, and Irish coalfields. It forms whole beds in the Alps, as in the Valais, Piedmont, Savoy, and Dauphiné; in the Pyrenees, and in various parts of France. In Germany it occurs in Silesia, Bohemia, Saxony, and the Harz, but not in very large amount. It is especially abundant in the United States, as in Rhode Island, Massachusets, and above all in Pennsylvania, where it seems to be an altered portion of the common bituminous coal of the western states; and it is also found with the oolite coal of Virginia. It is now used for manufacturing metals, for economic, and even for household purposes. In 1847 the United States produced 2,982,309 tons, of which 1,650,831 tons were from Schuylkill, and 643,973 tons from Lehigh.

482. Common Coal; Black, Stone, Bituminous Coal, *Phillips, &c.;* Schwarzkohle, *Werner, &c.;* Houille, *Hauy;* Bituminous Stone-Coal, Harzige Steinkohle, *Mohs.*

Structure compact, slaty, or confusedly fibrous; often dividing into columnar, cubical, or rhomboidal fragments. Fracture conchoidal, uneven, or fibrous. Rather brittle or sectile. H. = 2 — 2·5; G. = 1·2 — 1·5. Lustre vitreous, resinous, or silky in the fibrous variety. Colour blackish-brown, pitch-black, or velvet-black. Burns easily, emitting flame and smoke, with a bituminous odour. Heated in the closed tube with powdered sulphur, gives out sulphuretted hydrogen. Chem. com. carbon, with oxygen, hydrogen, nitrogen, and earthy matters in various proportions. The following important table, containing the elementary analyses and economic value of British coals, is taken from the valuable report of Sir H. De la Beche and Dr L. Playfair. (Mem. Geol. Sur. vol. ii.)

		Spec. grav.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Coke per cent.	Evapor. power	
Welsh Coals.	1	1·375	91·44	3·46	0·21	0·79	2·53	1·52	92·9	9·46	Anthracite.
	2	1·275	89·78	5·15	2·16	1·02	0·30	1·50	77·5	10·21	Ebbw Vale.
	3	1·304	88·66	4·63	1·43	0·33	1·03	3·96	88·10	9·94	Binca Coal.
	4	1·326	88·26	4·66	1·45	1·77	0·60	3·26	84·3	10·14	Duffryn.
	5	1·358	85·52	3·72	trace	0·12	4·55	6·09	85·0	6·36	Pentrefelin.
	6	1·30	84·87	3·84	0·41	0·45	7·19	3·24	85·5	9·35	Graigola.
	7	1·32	80·70	5·66	1·35	2·39	4·38	5·52	64·8	7·47	Ponty Pool.
	8	1·34	75·15	4·93	1·07	2·85	5·04	10·96	62·5	8·84	½ Rock vein.
	9	1·29	73·84	5·14	1·47	2·34	8·29	8·92	56·0	8·0	Coleshill.
Eng. Scotch.	10	1·277	74·55	5·14	0·10	0·33	15·51	4·37	49·8	7·08	Dalkeith jewel seam
	11	1·316	76·94	5·20	trace	0·38	4·37	3·10	53·5	7·71	Do. coronation seam
	12	1·20	76·09	5·22	1·41	1·53	5·05	10·70	58·45	8·46	Wallsend, Elgin.
	13	1·25	79·58	5·50	1·13	1·46	8·33	4·00	52·03	7·56	Fordel Splint.
	14	1·29	79·85	5·28	1·35	1·42	8·58	3·52	56·6	7·40	Grangemouth.
	15	1·25	81·70	6·17	1·04	2·85	4·37	3·07	59·2	7·3	Broomhill. (of Dean
	16	1·283	73·52	5·69	2·04	2·27	6·48	10·00	57·8	8·52	Parkend, Sydney For.
I sh	17	1·59	80·03	2·30	0·23	6·76	In ash	10·80	90·1	9·85	Slievardagh.

The following are a few foreign coals for comparison.

	Carbon.	Hydrogen.	Oxygen.	Earthy matter.	
1	96·02	0·44	2·94	0·60	Karsten, Werden, Westphalia.
2	89·16	3·20	6·45	1·18	Do. Eschweiler, Duren.
3	81·32	3·21	14·47	1·00	Do. Wellesweiler, Saarbrück.
4	78·39	3·21	17·77	0·63	Do. Beuthen, Upper Silesia.
5	73·88	2·76	20·48	2·88	Do. Brzenskowitz, Do.
6	89·27	4·85	4·47*a*	1·41	Regnault, Alais.
7	87·45	5·14	5·63*a*	1·78	Do. Rive de Gier.
8	84·83	5·61	6·57*a*	2·99	Do. Do. Cimetiere.
9	82·12	5·27	7·48*a*	5·13	Do. Lavasse.
10	76·48	5·23	16·01*a*	2·28	Do. Blanzy.

(*a*) Oxygen and nitrogen.

The quality of some coals, as it were, to fuse and run together in the fire, or *cake*, as it is named, is supposed to depend on the amount of bitumen, or, as Karsten states, of the proportion of hydrogen to oxygen. It is usual to distinguish—*Slate-coal* with a thick slaty structure, and an uneven fracture in the cross direction; *Cannel coal* with a resinous, glimmering lustre, and a large or flat conchoidal fracture, breaking into irregular cubical fragments, but more solid, and taking a higher polish than the other varieties; *Coarse* or *foliated coal*, of a massive or lamellar structure, breaking into cubical or irregular angular masses, with a more splendent lustre, and less compact texture than the former, and more easily frangible; *Earthy coal*, in loose powdery masses, often brown or dirty in colour, and apparently a semi-decomposed mass.

This mineral occurs in most abundance in the so-called true coal formation, but coal not mineralogically different is found in other geological deposits, as for instance in the oolite at Richmond, Virginia. It is abundant in many lands, as in England, South Wales,

Scotland, and Ireland; in Belgium and France, in Germany and Southern Russia. The United States possess immense fields in the valley of Mississippi. It is also found in China, Japan, Hindostan, Australia, Borneo, and several of the Indian islands, though probably not in all cases of uniform geological age.

Its uses are too well known to need notice. The varieties with most carbon give out the most heat, but are more difficult to kindle, and require a stronger draft of air. For preparing gas those coals are best in which the hydrogen bears a high proportion to the oxygen, and which are free from sulphur or iron pyrites.

483. BROWN COAL; Lignite, Jet, *Phillips, &c.;* Braunkohle, Erdkohle, Moorkohle, Pechkohle, Gagat, *Werner, &c.;* Jayet, *Hauy;* Lignites, *Dufrénoy.*

Distinctly vegetable in origin, the external form, and very often the internal woody structure, being preserved. The texture is compact, woody, or earthy. Fracture conchoidal, woody, or uneven. Soft and often friable. G. = 0·5 — 1·5. Lustre sometimes resinous, mostly glimmering or dull. Colour, brown, black, or rarely grey. Burns easily with an unpleasant odour. Colours solution of potash deep-brown. Heated with sulphur evolves much sulphuretted hydrogen. Chem. com. like common coal, but with a large proportion of oxygen and hydrogen. Analyses in 100 parts.

	Carbon.	Hydrogen.	Oxygen.	Watr.	Ashes.	
1	48·85	2·62	18·23	24·80	5·50	L. Gmelin, Sipplingen.
2	70·49	5·59	18·93*a*	....	4·99	Regnault, Dax.
3	63·88	4·58	18·11*a*	...	13·43	Do. Grand-Racher, near Aix.
4	70·02	5·20	21·77*a*	...	3·01	Do. Dept. Basses Alpes.
5	61·20	5·00	24·78*a*	...	9·02	Do. Alpheus, Greece.
6	73·79	7·46	13·79*a*	...	4·96	Do. Elnbogen, Bohemia.
7	71·71	4·85	21·67*a*	...	1·77	Do. Meissner (Pechkohle).
8	70·12	3·19	7·59	3·63*b*	15·47	Kühnert, Do. (Stangenkl.
9	56·60	4·75	27·15	9·07*b*	2·43	Do. Do. (Pechkohle).
10	60·83	4·36	24·64	9·36*b*	0·81	Do. Hirschberg.
11	57·26	4·52	26·10	10·79*b*	1·33	Do. Habichtswald.
12	54·18	4·20	26·98	11·11*b*	3·33	Do. Meissner.
13	63·35	5·68	27·93*a*	...	3·04	Woskressensky, Tiflis.
14	47·46	4·56	33·03*a*	...	14·95	Do. Irkutsk.
15	20·60	2·75	19·73*a*	..	56·92	Do. Kurland (Bitum. slate).

(*a*) With nitrogen; (*b*) volatile at 212° F.

Brown coal presents many varieties. The *Jet*, or Pechkohle of Werner, is of a pitch-black colour, with a conchoidal fracture and resinous lustre. It often shows a distinct tendency to divide into prismatic or columnar masses with four or six sides. The common brown coal is of a brown colour, and shows the woody texture with more or

less distinctness. Sometimes it is foliated with impressions of leaves and fishes; at other times earthy, like decomposed wood.

Brown coal generally contains the leaves, branches, and stems of trees, sometimes entirely, at other times only in part converted into coal; or they are partly coal, partly silicified or changed into iron ore. This kind of coal is found in the new red sandstone and keuper, more abundantly in the oolite (Brora and Yorkshire) and chalk, and in greatest profusion in the tertiary formations. Germany is very rich in brown coal deposits, especially in the north, in Thuringia, and on the Rhine. It is often connected with basalt or similar igneous rocks, as in the Meissner and other parts of Hessia. Hungary, France, Italy, and Greece also possess it in considerable abundance. The Surturbrand of Iceland seems a variety.

It is used as fuel, but is much inferior to common coal, yielding less coke (35 — 50 per cent.), and being often very impure, so that it can only be burnt in particular kinds of stoves, or after being formed into masses like bricks and dried. In some districts it is employed as manure; and, where it contains much sulphuret of iron, for preparing alum.

484. PEAT; Torf, *Hausmann*; Tourbe, *Beudant*.

This substance, consisting of a mass of more or less decomposed vegetable matter of a brown or black colour, is closely connected with the varieties of coal just described. Like them, it is rather a rock-mass than a simple mineral; but, for the sake of comparison, we give the following analyses in 100 parts.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ashes.	
1	66·55	10·39	18·59	2·76	1·70	Fickenscher, Fichtelgebirge.
2	57·03	5·63	29·67	2·09	5·58	Regnault, Vuleaire, Abbeville.
3	58·49	5·93	31·37	...	4·61	Do. Long.
4	57·79	6·11	30·77	...	5·33	Do. Champ-du-Feu.
5	57·16	5·65	33·39	...	3·80	Mulder, Friesland, compact.
6	59·86	5·52	33·71	...	0·91	Do. Do. less compact.
7	50·85	4·64	30·25	...	14·25	Do. Holland.

Mulder has found among the proximate elements of peat four different resins with humic and ulmic acid. The ashes, besides silica, alumina, and iron peroxide, contain the carbonate and phosphate of lime, and chloride of calcium. Peat shows a great attractive and retentive power for water, one part of dry turf absorbing two parts of water. Peat has been chiefly formed of five kinds of plants, the sphagnum, and similar mosses; the stems and roots of heaths; the similar parts of glumaceous plants; the wood of trees, aided by some

of the former; and, lastly, of fuci and sea-weeds. The latter has been denied, but Hausmann states that beds of this nature occur on the coasts of Sweden and Norway, often 30 feet above the present level of the sea.

IV. Family.—The Mineral Resins.

485. Bitumen, Naphtha; Erdöl, Steinöl, *Werner;* Bitumine liquide, *Hauy;* Naphte, *Beudant.*

Fluid in various degrees; colourless, yellow, or brown; transparent or translucent; G. = 0·7 — 0·9. Volatilizes in the atmosphere with an aromatic bituminous odour. Easily inflammable, and burns with an aromatic odour. Chem. com. carbon and hydrogen in various proportion, but usually about 1 C to 2 H.

The very fluid transparent and light-yellow varieties are named *Naphtha.* Of these the following are analyses.

	Carbon.	Hydrogen.	Total.	
1	84·65	13·31	97·96	Saussure, volatile portion, G. = 0·753.
2	88·02	11·98	100	Do. less volatile, G. = 0·836.
3	85·40	14·23	99·63	Blanchet and Sell, more vol., G. = 0·794.
4	87·7	13·0	101·0	Do. less volatile part, G. = 0·849.
5	86·4	12·7	99·1	Dumas.
6	85·96	14·04	100	Hess.
7	82·2	14·8	97	Thomson.

Chemical research has shown that naphtha consists of various volatile combinations. In the variety from the Tegern lake in Bavaria v. Kobell found, besides pure naphtha, a volatile oil, a resinous substance, and a considerable amount of paraffine. Gregory found the latter in the butter-like naphtha from Rangun in Hindostan. At this place there are said to be above 500 naphtha wells, producing a large amount of this substance. It is common in the vicinity of volcanic mountains or mud volcanos, as at Baku on the Caspian Sea. China and Persia furnish it in considerable abundance. It is found at Amiano near Parma, and many other parts of Italy; at Salies in the Pyrenees; and in several places in the United States of North America. It is used for burning, for dissolving vegetable resins, and preparing varnishes.

Petroleum includes the darker coloured yellow or blackish-brown, less fluid or volatile varieties. These appear a compound of naphtha and asphalt. Analyses, next page.

	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Ashes	Total.	
1	88·3	11·9	0·011	...	...	99·411	Boussingault, Bechelbrunn, Alsace.
2	88·7	12·6	0·04	...	...	101·7	Hatten, Do. Do.
3	78·50	8·80	1·65	2·60	8·45	100	Ebelmen, Bastennes.

This variety occurs in the cavities and fissures of many rocks, both stratified and volcanic. It is common in the coal formation of England, as at Ormskirk in Lancashire, at Coalbrookdale, Pitchford, and Madeley in Shropshire, and other localities; and in Scotland at St Catherine's Well, south of Edinburgh. It also occurs in many other parts of Europe and in the United States.

486. ELATERITE, *Hausmann;* Elastic bitumen, *Phillips;* Mineral Caoutchouc, *Allan;* Elastiches Erdpech, *Werner;* Bitume élastique, *Hauy.*

Occurs in compact, reniform, or fungoid masses, elastic and flexible like caoutchouc. Very soft. G. = 0·8—1·23. Translucent on the edges or opaque; resinous; blackish, reddish, or yellowish-brown. Strong bituminous odour. Chem. com. CH^2, with a little oxygen. Analyses.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Total.	
1	52·25	7·50	40·10	0·15	100	Henry, Derbyshire.
2	58·26	4·89	36·75	0·10	100	Do. Montrelais.
3	85·47	13·28	...	...	98·75	Johnston, Derbyshire.
4	84·38	12·58	...	...	96·96	Do. Do.
5	83·67	12·54	...	...	96·21	Do. Do.
6	85·96	12·34	...	...	98·30	Do. Do.
7	86·18	12·42	...	...	98·60	Do. Do.

Johnston considers the loss in his analyses as oxygen; and Rammelsberg also ascribes it to some compound containing this body.

Elaterite is especially found in the veins of lead ore in the mountain limestone of Derbyshire; but also at Montrelais near Nantes in France in carboniferous sandstone; and at Woodbury in Connecticut in a bituminous limestone.

487. ASPHALTUM. Bitumen, *Phillips* in part; Erdpech, *Werner;* Asphalte, *Dufrénoy.*

Compact and disseminated in various forms. Fracture conchoidal, sometimes vesicular. Sectile. H. = 2; G. = 1.1—1·2. Opaque, resinous, and pitch-black; with strong bituminous odour, especially when rubbed. Takes fire easily, and burns with a bright flame and thick smoke. Not soluble in water. Soluble in ether, except a small

remainder, which is dissolved in oil of turpentine. Chem. com. carbon, oxygen, and hydrogen in uncertain proportions. Analyses.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ashes.	Total.	
1	75·85	7·25	12·96		3·94	100	Regnault, Cuba.
2	79·18	9·30	8·72		2·80	100	Do. Do.
3	76·13	9·41	10·34	2·32	1·80	100	Ebelmen, Auvergne.
4	77·64	7·86	8·35	1·02	5·13	100	Do. Abruzzi.
5	55·48	6·15	21·42	1·12	15·83	100	Do. Pontnavey.
6	78·50	8·80	2·60	1·65	8·45	100	Do. Bastennes.
7	88·66	9·65	1·69		...	100	Boussingault, Peru (m. of 2).

Asphalt seems in general a recent production, sometimes associated, but very often wholly unconnected with volcanic action. It is found in beds, veins, nests, or disseminated through various sandstone and limestone beds in the secondary, tertiary, and most recent formations. Occasionally it forms casts of shells, fishes, plants, or other organic remains. It is also found in mineral veins even in the oldest rocks, as in the beds of magnetite and hæmatite in Sweden.

The asphaltum of the Dead Sea was well known to the ancients, and pits near the Euphrates and Tigris furnished that used as mortar at Babylon. It is still abundant in Persia and other parts of Asia. The pitch lake of Trinidad, 1½ mile in circumference, is another celebrated locality. In cold weather the asphaltum near the sides is solid, and in some places trees are growing on the surface, but in the centre of the lake it is still soft and boiling. In 1843, a thick bed of asphaltum of considerable extent was discovered at Limmer near Hanover, a few feet below the surface. It is very abundant near Seyssel in the Ain department on the Rhone; and also occurs at Val Travers in Neufchatel, Lobsann in Alsace, in the Harz, and other places. It has been found in mineral veins in Cornwall; in veins in Haughmond hill, Shropshire; in ironstone nodules in East Lothian; and in irregular masses in the carboniferous limestone near Burntisland in Fifeshire.

488. Piauzite, *Haidinger*.

Massive, but with many parallel fissures; fracture imperfect conchoidal; sectile. H. = 1·5; G. = 1·22. Dimly translucent on very thin edges; lustre resinous; colour blackish-brown; streak yellowish-brown. Fuses at 600° Fahr., and burns with a peculiar aromatic odour, a lively flame, and much dense smoke. Perfectly soluble in ether and caustic potash. It is found in vein-like masses in the brown coal at Piauze north of Neustadt in Carniola.

489. IXOLYTE, *Haidinger.*

Massive and amorphous, with conchoidal fracture. H. = 1; G. = 1·008. Lustre resinous; colour hyacinth-red; streak ochre-yellow. Rubbed between the fingers it emits an aromatic odour, and becomes soft at 169°, but is still viscid at 212°. Found in fissures of the brown coal at Oberhart near Gloggnitz in Austria.

490. AMBER, *Phillips;* Bernstein, *Werner;* Succinite, *Breithaupt;* Succin, *Hauy;* Yellow Mineral Resin, *Mohs.*

Occurs in round irregular lumps and grains, or in drops and apparently indurated fluid masses. Fracture perfect conchoidal. Slightly brittle. H. = 2 — 2·5; G. = 1 — 1·1. Transparent to translucent or almost opaque; lustre resinous; colour honey-yellow, but sometimes hyacinth-red or brown, at other times yellowish-white, and occasionally streaked or spotted. When rubbed it emits an agreeable odour, and becomes negatively electric. It melts at 550°, emitting water, an empyreumatic oil, and succinic acid. It burns with a bright flame and pleasant odour, leaving a carbonaceous remainder. Only a small part is soluble in alcohol. Chem. com., according to Schrötter, C^{10} H^{8} O, with 79 carbon, 10·5 hydrogen, and 10·5 oxygen. Analyses.

	Carbon.	Hydrogen.	Oxygen.	Lime.	Alumina.	Silica.	Total.	
1	80·59	7·31	6·73	1·54	1·10	0·63	97·90	Drapiez, Trahenières.
2	76·62	10·23	10·95	...	...	...	100	Schrötter.

The proximate elements of amber consist of the succinic acid, two resins soluble in alcohol and ether, and in greatest amount of a bituminous substance insoluble in alcohol, in oils, or in caustic potash.

The chemical properties and mode of occurrence of amber leave no doubt of its being the produce of extinct coniferæ. It has been found incrusting or penetrating fossil wood, exactly like resin at the present day, and enclosing the cones and leaves of the trees. Numerous insects, the inhabitants of these ancient forests, have been embalmed in a similar manner. To the tree which principally produced it, Göppert gives the name of *Pinites succinifer*, but probably there has been more than one species. It is often stated to occur in the brown coal beds of Northern Germany, but Göppert says that he knows of no instance of this, the substance he found in these beds being retinite, whilst the amber is always in the drifted sand and gravels above, associated with wood, also apparently water-worn and drifted. It is also said to have been observed in the newer secondary formations, as by Dunker in

the conglomerate sandstone of the lower oolite at the Porta Westphalica near Minden; by Pfaff in the gypsum of the Segeberg in Holstein; and by Glocker in the coal connected with the greensand near Truban, Walchow, and other places in Moravia.

The finest amber, often highly transparent, and showing blue or opalescent tints, occurs on the Sicilian coast between Catania and Semito. It is found most abundantly, and in the largest masses, generally of yellow, far more rarely of white tints, on the Prussian coast, especially between Palmnicken and Gross-Hubenicken, from which point it decreases on both sides. It is also thrown on shore by storms, or fished up with the sea-weed. In East and West Prussia there is scarcely a village where it has not been found, and it extends thence into Brandenburg, Pommerania, Mecklenburg, and Holstein, to the low land of Saxony and Silesia, to Poland, Galicia, Volhynia, Lithuania, Esthonia, and the whole Baltic plain. It has also been found in Southern Germany, in France, Italy (near the Po), Spain, Sweden, and Norway. In other quarters of the globe, the shores of the Caspian Sea, Siberia, Kamtschatka, China, Hindostan, Madagascar, North America, and Greenland are mentioned as localities. In Britain it is thrown out by the sea on the shores of Norfolk, Suffolk, and Essex, and has also been met with in the sands at Kensington near London.

Amber is used for ornamental purposes, and for preparing succinic acid, and varnishes. A specimen, 14 inches long, and weighing about 14 lbs., was found in 1803 near Gumbinnen, and is now in the Berlin Museum. It is valued at 10,000 dollars, or L.1500 sterling.

491. RETINITE, *v. Leonhard, &c.;* Retinasphalt, *Hatchett, Phillips, Mohs;* Resinite, *Hauy.*

Occurs in roundish or irregular lumps. Fracture uneven or conchoidal. Very easily frangible; H. = 1·5 — 2; G. = 1·05 — 1·15. Translucent or opaque. Lustre resinous or glistening. Colour various shades of yellow or brown. It usually melts at a low heat and burns with an aromatic or bituminous odour. Chem. com. in general, carbon, hydrogen, and oxygen, but in very uncertain amount; this name having been given to various fossil resins. Analyses.

	Soluble in alcohol.	Not sol. in alcohol.	Earthy matter.	Total	
1	55	41	3	99	Hatchett, Bovey.
2	59·32	27·45	13·23	100	Johnston, Do.
3	91	9	...	100	Bucholz, Halle.
4	55·5	42·5	1·5	99·5	Troost, Cape Sable.

Hatchett thought that the mineral from Bovey consisted of a resinous substance and another like asphalt, and hence named it Retin-asphalt; but Johnston states that the portion soluble in alcohol is not similar to asphaltum. It is found in the above and other localities usually in beds of brown coal; but near Osnabrück forms a layer in peat.

492. WALCHOWITE, *Haidinger.*

Occurs in rounded pieces several inches in size, with a conchoidal fracture; H. = 1·5 — 2; G. = 1·035 — 1·069. Translucent, resinous; colour yellow, with brown stripes; and a yellowish-white streak. It fuses at 482°, and burns readily. Soluble partially (7·5 per cent.) in ether; and in sulphuric acid forms a dark brown solution. Chem. com. C^{12} H^9 O, with 80·4 carbon, 10·7 hydrogen, and 8·9 oxygen, according to Schrötter's analyses.

It occurs in brown coal at Walchow in Moravia, and was formerly thought retinite or copaline. Boussingault found a similar mineral near Bucaramanga in New Granada.

493. COPALINE, *Hausmann;* Fossil Copal, Highgate Resin, *Aikin, Jameson;* Copal fossile, *Dufrénoy.*

Occurs in irregular fragments; H. = 1·5; G. = 1·046. Translucent, resinous, and light-yellow or yellowish-brown. Burns easily with a bright yellow flame and much smoke. Alcohol dissolves very little of it, which is precipitated by water. Becomes black in sulphuric acid. Chem. com. C^{40} H^{64} O; or, by Johnston's analyses (mean of two), 85·54 carbon, 11·63 hydrogen, 2·76 oxygen, 0·14 ashes (= 100·07). It is found in the blue clay at Highgate near London. Johnston describes a somewhat similar resin from the lead mines of Settling Stones in Northumberland, where it is found in flat drops or crusts on calc-spar. It is infusible at 500° F., and has G. = 1·16 — 1·54; and contains by analysis 85·13 carbon, 10·85 hydrogen, and 3·26 ashes, for which he proposes the formula C^2 H^3.

494. BERENGELITE, *Johnston.*

Occurs in large amorphous masses with conchoidal fracture. Colour dark-brown inclining to green. Yellow streak. Has a resinous unpleasant odour and bitter taste. Fuses below 212°, and then continues soft at ordinary temperatures. Easily soluble in alcohol; the solution has a bitter taste. Chem. com. C^{40} H^{62} O^8. Mean of two analyses, 72·40 carbon, 9·28 hydrogen, 18·31 oxygen. It is said to form a lake in the province of St Juan de Berengela in South America; and is used at Arica to caulk vessels.

495. Guyaquillite *Johnston.*

Occurs in large amorphous masses, yielding easily to the knife, and very friable; G. = 1·092. Colour pale-yellow; lustre slightly resinous. At 157° it begins to melt, and is quite fluid at 212°. Becomes viscid when cold. Slightly soluble in water and largely in alcohol, forming a yellow fluid with a bitter taste. Forms a reddish-brown solution in sulphuric acid. Chem. com. $C^{20}\,H^{26}\,O^{3}$. Mean of two analyses by Johnston, 77·01 carbon, 8·18 hydrogen, and 14·80 oxygen. Found at Guyaquil in South America.

The *Bogbutter* described by Williamson, from the Irish peat mosses, is a similar compound. It melts at 124°, is easily soluble in alcohol, and contained 73·78 carbon, 12·50 hydrogen, and 13·72 oxygen.

496. Hartine, *Schrötter.*

Occurs in spermaceti-like masses; G. = 1·115. Colour white; without taste or smell. Becomes soft at 392°, and at 410° melts to a clear yellow fluid, being at the same time partly decomposed. Burns with a bright flame. It is not soluble in water, very little in ether, and less in alcohol. Petroleum dissolves a larger amount, which afterwards crystallizes in long needles. Chem. com. $C^{20}\,H^{34}\,O^{2}$; or, by Schrötter's analysis, 78·26 carbon, 10·92 hydrogen, 10·82 oxygen. It occurs in the brown coal of Oberhart near Gloggnitz in Austria.

497. Middletonite, *Johnston.*

Occurs in small round masses or thin layers. Brittle, but easily cut with a knife; G. = 1·6. Transparent in small fragments; lustre resinous. Colour reddish-brown by reflected, deep-red by transmitted light. Streak light-brown. It becomes black on exposure to the atmosphere. Not altered at 400° F., but fuses at higher temperatures, and burns like resin on hot coals. Alcohol, ether, and oil of turpentine dissolve a small portion by boiling, and become yellow. Soluble in concentrated sulphuric acid. Chem. com. $C^{20}\,H^{20} + H\,O$; or, by Johnston's analysis, 86·44 carbon, 8·01 hydrogen, 5·56 oxygen. Found in the main coal seam at Middleton near Leads, and at Newcastle.

498. Ozokerite, *Glocker, Phillips, Dufrénoy.*

Amorphous, but sometimes fibrous. Fracture in one direction flat conchoidal, in another splintery. Very soft, pliable, and easily fashioned with the fingers. G. = 0·94 — 0·97. Lustre glimmering or glistening on the chief fracture; semitranslucent; yellowish-brown or hyacinth-red by transmitted, dark leek-green by reflected light; it

has a pleasant aromatic odour; fuses easily (at 144°, *Schrötter;* at 183°, *Malagutti*) to a clear oily fluid, again becoming solid when cold, and at higher temperatures burns with a clear flame, seldom leaving any ashes. Readily soluble in oil of turpentine, with great difficulty in alcohol or ether. Chem. com. CH, with 85·7 carbon and 14·3 hydrogen. It occurs in a bituminous sandstone near coal and rock salt at Slanik and Zietriska in Moldavia; and, according to Partsch, at Gersten near Garning in Austria. Also in the coal mine of Urpeth near Newcastle-on-Tyne in England. Analyses.

	Carbon.	Hydrogen.	Total.	
1.	85·75	15·15	100·90	Magnus, Slanik.
2.	86·07	13·95	100·02	Malagutti, Do. (m. of 3).
3.	86·80	14·06	100·86	Johnston, Urpeth.

499. HATCHETINE, *Conybeare.* Mineral tallow.

Occurs flaky, like spermaceti; or sub-granular, like bees' wax. Soft and flexible. G. = 0·6 (when fused, 0·983). Translucent; lustre weak pearly; colour yellowish-white, wax-yellow, or greenish-yellow; feels greasy; inodorous; readily soluble in ether. Chem. com. of a variety from Glamorganshire, 85·91 carbon and 14·62 hydrogen, or similar to ozokerite. This variety is fusible at 115°, and another from Loch Fyne near Inverary at about the same point. Another, forming small veins in the ironstone of Merthyr-Tydvil, only melts at 170°. It is thus probable that various substances have been included under this name. A mineral, similar to that from Merthyr-Tydvil, has been found by Dunker in clay ironstone from the lower wealden near Sooldorf in Schaumburg.

500. FICHTELITE, *Bromeis.*

Occurs in crystalline lamellæ, which swim in water, but sink in alcohol. They are white and pearly, and fuse at 115°, but again become crystalline on cooling. Very easily soluble in ether, and precipitated by alcohol. Chem. com. C^4H^3. Bromeis found 89·3 carbon and 10·7 hydrogen. It occurs between the annual layers of wood in pine trees in a peat moss near Redwitz in Bavaria.

501. HARTITE, *Haidinger.*

Resembles spermaceti or white wax, and shows a lamellar structure, and probably monoclinohedric crystallization. Sectile, but not flexible. H. = 1; G. = 1·046. Translucent; lustre dull resinous; colour white. It melts at 165°, and burns with much smoke. Very soluble in ether, much less so in alcohol. Chem. com. C^6H^5; or, by Schrötter's analysis, 87·50 carbon and 12·10 hydrogen. Found in

fissures and cavities of bituminous and siliceous wood in the brown coal of Oberhart near Glogguitz in Austria.

502. KÖNLITE, *Schrötter.*

Occurs in small crystalline foliæ and grains. Soft. G. = 0·88. Translucent; lustre resinous; colour white; without smell. Fuses at 126°—137° Fahr. Soluble in nitric acid, and precipitated by water in a white crystalline mass. Chem. com. C^2 H, with 92·31 carbon and 7·69 hydrogen. Kraus found in that from bituminous wood at Uznach near St Gallen in Switzerland, 92·49 carbon and 7·42 hydrogen; and Trommsdorff, in that from Redwitz in Bavaria, 92·43 carbon and 7·57 hydrogen.

503. SCHEERERITE, *Stromeyer; Phillips, Mohs.*

Monoclinohedric, in tabular or acicular crystals. Soft and rather brittle. G. = 1·0 — 1·2. More or less translucent; lustre resinous or adamantine; colour white, inclining to yellow or green. It feels greasy, has no taste, and when cold no smell, but when heated a weak aromatic odour. It fuses at 111° to a colourless fluid, which crystallizes again when cold; and, at 198°, can be distilled over without decomposition. Insoluble in water; but readily in alcohol, ether, nitric and sulphuric acid. Chem. com. CH^2, with 75 carbon and 25 hydrogen, which nearly agrees with an analysis by Macaire-Prinsep. Occurs in the wood of the brown coal at Uznach with könlite; with which it is occasionally confused. The following are similar compounds;—*Branchite* of Savi, from the brown coal of Monte Vaso in Tuscany, fuses at 167°, and is white, translucent, and feels greasy; *Tekoretine*, fusible at 113°, soluble in ether, but difficultly in alcohol; and *Phylloretine*, more soluble in alcohol, and fusible at 188°. The last two were found by Forchhammer in fossil pine trees in Denmark.

504. IDRIALITE, *Schrötter;* Idrialine, *Dana, Dufrénoy.*

Massive; fracture uneven or slaty. Sectile. H. = 1·0 — 1·5; G. = 1·4 — 1·6. Opaque; lustre resinous; colour greyish or brownish-black; streak blackish-brown, inclining to red. Feels greasy. It burns with a thick smoky flame, giving out sulphurous acid, and leaving some reddish-brown ashes. Chem. com. according to Schrötter, idrialine and cinnabar, mixed with a little silica, alumina, pyrite, and lime. The idrialine may be extracted by warm olive oil or oil of turpentine, and then appears as a pearly shining mass. Dumas gives its composition as C^3 H, with 94·75 carbon and 5·25 hydrogen. Bödeker says this is the composition of Idryl, a new substance produced from idrialine, and finds in the latter, as the mean of four analyses,

agreeing very closely, 91·83 carbon, 5·30 hydrogen, and 2·87 oxygen. In one specimen of idrialite, with G. = 1·721, Schrötter found 77·32 idrialine, 17·85 cinnabar, and 2·75 other substances; in another specimen, G. = 3·231, 31·56 idrialine, 68·34 cinnabar, and 1·57 other substances. It has only been found at Idria in Carniolia, in thin layers among the slates containing the mercury ores. Its inflammability renders it dangerous, as the mines, when on fire in 1803, probably from spontaneous combustion, were only extinguished by being laid under water.

V. Family.—Inflammable Salts.

505. Mellite, *Hauy, Phillips;* Honey Stone, *Jameson;* Honigstein, *Werner;* Pyramidal Melichrone-resin, *Mohs.*

Tetragonal; P 93° 1′ (*Breithaupt*, 93° 6′ *Kupffer*). The fundamental form appears either alone or in combination with 0P, or also with P∞ and ∞P∞. The crystals are usually imbedded singly, rarely conjoined in small groups or druses. It also occurs massive and granular. Cleavage, pyramidal along P very imperfect; in general only the conchoidal fracture is seen. Rather brittle. H. = 2·0 — 2·5; G. = 1·4 — 1·64. Transparent to translucent; distinct double refraction. Lustre between resinous and vitreous. Colour honey-yellow to wax-yellow, or occasionally reddish. Streak whitish. In the closed tube it yields water. B.B. carbonizes without any sensible odour, at length burns white, and acts like pure alumina. Easily and entirely soluble in nitric acid or solution of potash. Chem. com. $\ddot{A}l\ \bar{M}^3 + 18\ \dot{H}$, with 40·53 mellic acid ($\bar{M} = C^4O^3$), 14·32 alumina, and 45·15 water. Analyses.

	Mellic acid.	Alumina.	Water.	Total.	
1	46	16	38	100	Klaproth, Artern.
2	41·4	14·5	44·1	100	Wöhler, Do.

Wöhler also found traces of iron and a resinous substance. This is a rare mineral, occurring chiefly at Artern in Thuringia in brown coal; also in brown coal at Lauschitz near Bilin in Bohemia. Glocker has found in the coal of the greensand at Walchow in Moravia yellow and white mellite, differing from the common variety in containing more alumina, less water and mellic acid, and a small proportion of silica.

506. OXALITE, *Hausmann;* Humboldtine, *de Rivero*, *Mohs;* Oxalate of Iron, *Phillips*; Fer oxalaté, *Hauy.*

Occurs in capillary crystals, but system not known; and also botryoidal or in plates, partly fine granular, partly fibrous, or compact. Fracture uneven or earthy. Slightly sectile. H. = 2; G. = 2·15 — 2·25. Opaque; lustre weak resinous or dull. Colour ochre or straw-yellow. B.B. on charcoal becomes first black then red; and with borax or salt of phosphorus shows reaction for iron. Easily soluble in acids. Solution of potash separates the protoxide of iron, which is first green and then reddish-brown. Chem. com. $2\,\dot{F}e\,\ddot{C} + 3\,\dot{H}$, with 42·7 oxalic acid, 41·4 iron protoxide, and 15·9 water. Mariano de Rivero found in a specimen from Kolosoruk 46·14 oxalic acid and 53·86 iron protoxide, but the analysis seems incorrect. Rammelsberg obtained 42·40 oxalic acid, 41·13 iron protoxide, and 16·47 water; and, in two subsequent trials, 40·24, and 40·8 per cent. of iron protoxide from the same variety. He thinks that the mineral examined by Thomson, who doubts the presence of oxalic acid, was the yellow iron ore (p. 327), with which this species is sometimes confused.

It occurs in the brown coal at Kolosoruk near Bilin, in Bohemia, and also at Gross Almerode in Hessia.

Brooke observed some minute crystals of *Oxalate of Lime* on a specimen of calcspar from an unknown locality.*

* The *Struvite* of Ulex, though not properly belonging to the mineral kingdom, may be here noticed. It occurs in rhombic crystals, P 104° 10′, 92° 18′, and 135° 39′ (*Marx*), with one perfect cleavage. H. = 1·5 — 2; G. = 1·66 — 1·75. Transparent or opaque; lustre vitreous; colourless, but coloured yellow or brown. In the closed tube yields water and ammonia. B.B. fuses to a white enamel. Soluble in hydrochloric acid; and very slightly in water. Chem. com. probably like that of the artificial phosphate of ammonia and magnesia, in which Otto found 28·12 phosphoric acid, 16·28 magnesia, 6·83 ammonia, and 48·77 water, but mixed with protoxide of iron, from a mere trace to 10 per cent. This substance was found in peat earth covered with stable refuse in digging the foundation of the St Nicolai Church at Hamburg in 1845, and since in other places near putrescent animal matter, and in guano from Africa. The crystals seem very liable to decomposition. Their true character has occasioned much controversy in Germany.

APPENDIX.

Mohs and some other mineralogists have introduced air, water, and various other gaseous and fluid substances into their systems of mineralogy. Properly these are not simple minerals, and the description of their nature and properties belongs to chemistry, or other branches of science. They have in consequence been omitted in the above system; but we may here shortly describe the characters of water in its two conditions of solid and fluid.

Water; Wasser, *Hausmann;* Eau, *Beudant.*

Fluid and amorphous. G. = 1·000 when pure, but sea water as high as 1·027 and 1·0285 at 62° Fahr. When pure it is without taste or smell, and colourless in small quantities, but in larger masses green or blue. Chem. com. HO, or hydrogen-oxide, with 88·9 oxygen and 11·1 hydrogen. At 32° Fahr. it freezes and changes to

Ice.

Solid and hexagonal. Smithson describes the crystals as regular pyramids, with angles of 142° 30′ and 80° nearly: Clarke as rhombohedrons of 120° and 60°. It usually appears in six-sided tables, either of 0P . ∞P or 0R . ∞R; and also in acicular crystals, with a strong tendency to combine in macles, forming delicate groups, or stars with six rays. Cleavage, probably basal. H. = 1·5; G. = 0·9268 (*Ossann*, mean of ten experiments), 0·918 (*Brunner*, at 32° Fahr., and quite pure). Transparent; lustre vitreous; colourless, but in large masses greenish or bluish. Refracts double. Thin plates of ice formed on still water show the coloured rings and cross very distinctly in polarized light.

The water found on the earth is never pure, but contains more or less of various substances,—atmospheric air, carbonic acid, nitrogen gas; silica, alumina, and salts (carbonates, sulphates, nitrates, phosphates) of lime, magnesia, soda, potash, protoxides of iron and manganese; or chlorides and fluorides of their metallic bases; and in the sea and some saline springs also iodine and bromine.

CHEMICAL ARRANGEMENT

OF

MINERALS,

ACCORDING TO THE

PRINCIPLES OF BERZELIUS,

BY

C. F. RAMMELSBERG, PHIL. DR.,

PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF BERLIN, &c.

In translating the following classification the names of the species used in the former part of this treatise have been adopted, and the corresponding numbers prefixed. The table thus forms a Chemical Index to the work, and will at the same time enable any person, who may prefer a chemical arrangement, to study the minerals described in that order. It will be observed that, in the formulæ of the silicates, silica is considered as composed of $\dot{S}i$, instead of $\ddot{S}i$, as in the body of the work; but the difference in atomic composition is in most cases only apparent. The recent observation of Scheerer, that 2 $\dot{S}i$ is isomorphous with, or replaces 3 $\ddot{A}i$ (*i.e.* $\ddot{S}i$ isomorphous with $\ddot{A}i$), supports L. Gmelin's opinion regarding the constitution of this most important substance. A few minerals which had been omitted in the previous pages are referred to by letters A, B, C, &c., and are noticed at the end of the table.

A. Minerals of Inorganic Nature.

I. *Elementary Bodies.*

399	Native Iron	Fe.
395	Native Lead	Pb.
397	Native Bismuth	Bi.
398	Native Copper	Cu.

389	Native Mercury	Hg.
387	Native Silver	Ag.
383	Native Palladium	Pd.
382	Native Platina[1]	Pt.
386	Native Gold[2]	Au.
	Carbon.....	C.
479	*a*) Diamond.	
480	*b*) Graphite.	
394	Native Tellurium[3]	Te.
391	Native Antimony	Sb.
393	Native Arsenic	As.
477	Native Sulphur	S.

II. *Combinations of Metals with each other.*

399	Meteoric Iron	Fe, Ni, Co.
390	Amalgam.	
	a) From Allemont, Moschellandsberg.....	$Ag\,Hg^2$.
	b) From Moschellandsberg	$Ag\,Hg^3$.
385	Platina-Iridium (N. Iridium)	Ir, Pt.
384	Osmium-Iridium.....	*a*) Ir Os.
		b) $Ir\,Os^3$.
386	Palladiumgold.....	Pd, Au.
412	Breithauptite	$Ni^2\,Sb$.
388	Antimony-silver	*a*) $Ag^4\,Sb$.
		b) $Ag^6\,Sb$.
421	Arsenic-manganese (?)	$Mn^2\,As$.
403	Leukopyrite.....	*a*) Fe As.
		b) $Fe^4\,As^3 = Fe^2\,As + 2Fe\,As$.
	Arsenic-nickel.	
414	*a*) Nickeline (Copper nickel)	$Ni^2\,As$.
415	*b*) Rammelsbergite (Arsenic-nickel..... Cloanthite, Brthpt	Ni As.

[1] Contains also Fe, Rh, Rt, Ir, Pd, Os; Svanberg supposes chemical combinations $Fe\,Pt^2$, $Fe\,Pt^3$, and $Fe\,Pt^4$, in them.

[2] Mixed with Ag in variable proportions, in consequence of the isomorphism.

[3] Usually mixed with Au, Te.

	Arsenic-cobalt.	
406	*a*) Smaltine	Co **As**.
407	*b*) Modumite	Co^3 As^8.
420	Arsenic-copper (Domeykite)	Cu^3 **As**.
420	Condurrite (?)	
	Arsenic-silver (?)[1]	Ag As.
392	Arsenic-antimony	**Sb As**.

III. *Combinations of the Elementary Bodies with Bodies forming Acids and Bases* (*Combinations of Tellurium, Selenium, Sulphur, and Oxygen.*)

A. *Tellurets* (*Tellurmetalle*).

	Tellurium-lead	Pb Te.
435	*a*) Altaite.	
434	*b*) Nagyagite.[2]	
437	Tellur-bismuth	Bi, Te.
436	Tellur-silver	*a*) Ag Te.
		b) (Ag, Au) Te.
454	Silvanite	Ag Te + 2 Au Te^3.
454	White Tellurium	$(Ag, Pb)^2$ **(Te, Sb)** + 2 **Au (Te, Sb)**^{6}.

B. *Selenids* (*Selenmetalle*).

424	Selen-lead	Pb Se.
433	Selen-copper	**Cu** Se.
426	Selen-mercury	Hg, Se.
427	Selen-silver	Ag Se.
424	Selen-cobalt-lead	Co Se + 6 Pb Se.
425	Selen-copper-lead.	
		a) Cu Se + Pb Se.
		b) Cu Se + 2 Pb Se.
		c) Cu Se + 4 Pb Se.
424	Selen-mercury-lead	Pb, Hg, Se.
432	Eukairite	**Cu** Se + Ag Se.

[1] The existence of this compound as a mineral is not proven.

[2] Pb Te, mixed with **Au** Te^3 and Pb S.

C. *Sulphurets* (*Schwefelmetalle*).

1. Simple Sulphurets.

468	Alabandine	$\acute{Mn}$.
402	Pyrrhotine	$\acute{Fe}$.
	Bisulphuret of Iron	$\acute{\acute{Fe}}$.
400	*a*) Pyrite.	
401	*b*) Marcasite.	
416	Millerite	$\acute{Ni}$.
417	Eisennickelkies	$\acute{Fe}$, $\acute{Ni}$, or $\acute{Ni} + 2\,\acute{Fe}$.
408	Linneite	$\acute{\acute{\acute{Co}}}$. Perhaps $\acute{Co}\,\acute{\acute{\acute{Co}}}$.
466	Blende	$\acute{Zn}$.
470	Greenockite	$\acute{Cd}$.
422	Galena	$\acute{Pb}$.
451	Bismuthine[1]	$\acute{\acute{\acute{Bi}}}$.
430	Redruthite (Copper Glance)	$\acute{Cu}$.
431	Kupferindig	$\acute{Cu}$.
474	Cinnabar	$\acute{Hg}$.
428	Argentite	$\acute{Ag}$.
438	Molybdenite	$\acute{\acute{Mo}}$.
439	Stibine (Grey Antimony Ore)	$\acute{\acute{\acute{Sb}}}$.
475	Realgar	$\acute{\acute{As}}$.
476	Orpiment	$\acute{\acute{\acute{As}}}$.

2. Combinations of Sulphurets.

(Sulphur-salts.)

430	Digenite	$\acute{Cu}\,\acute{Cu^3}$.
418	Chalcopyrite (Copper pyrites)	$\acute{Cu}\,\acute{\acute{\acute{Fe}}}$.
419	Bornite	$\acute{Cu^3}\,\acute{\acute{\acute{Fe}}}$ (often mixed with $\acute{Cu}$).
463	Stannine (Tin pyrites)	$\acute{Cu^2}\,\acute{\acute{Sn}} + (\acute{Fe}, \acute{Zn})^2\,\acute{\acute{Sn}}$.

[1] The B. from Bispberg is perhaps $\acute{Bi}$.

423	Cuproplumbite	$\dot{C}u\,\dot{P}b^2$.
409	Grünauite	$\dot{N}i$ ($\dddot{N}i$, $\dddot{B}i$), Frankenh. (?)
464	Cupreous bismuth	$\dot{C}u\,\dot{B}i$ (?).
452	Aciculite	$\dot{C}u^3\,\dddot{B}i + 2\,\dot{P}b^3\,\dddot{B}i$.
462	Sternbergite.....	$\dot{A}g\,\dddot{F}e^2$ (?).
429	Stromeyerite[1]	$\dot{A}g\,\dot{C}u$.
450	Berthierite.	
	a) From Chazelles.....	$\dot{F}e^3\,\dddot{S}b^2$.
	b) From Anglar. Braunsdorf	$\dot{F}e\,\dddot{S}b$.
	c) From Martouret	$\dot{F}e^3\,\dddot{S}b^4$.
411	Ullmannite	$\ddot{N}i + Ni\,\ddot{S}b$, or Ni (S, $\ddot{S}b$).
441	Zinckenite	$\dot{P}b\,\ddot{S}b$.
442	Plagionite	$\dot{P}b^4\,\dddot{S}b^3$.
440	Jamesonite	$\dot{P}b^3\,\dddot{S}b^2$.
446	Plumosite	$\dot{P}b^2\,\dddot{S}b$.
443	Boulangerite	$\dot{P}b^3\,\dddot{S}b$.
444	Geokronite* (from Meredo)	$\dot{P}b^5\,\dddot{S}b$.
444	Kilbrickenite	$\dot{P}b^6\,\dddot{S}b$.
453	Kobellite.....	$\dot{F}e^3\,\dddot{S}b^2 + \dot{P}b^3\,\dddot{B}i$.
448	Wolfsbergite	$\dot{C}u\,\dddot{S}b$.
457	Bournonite	$\dot{C}u^3\,\dddot{S}b + 2\,\dot{P}b^3\,\dddot{S}b$.
472	Miargyrite	$\dot{A}g\,\dddot{S}b$
471	Pyrargyrite, dark*.....	$\dot{A}g^3\,\dddot{S}b$.
460	Stephanite	$\dot{A}g^6\,\dddot{S}b$.
459	Freieslebenite	$\dot{P}b\,\dddot{S}b + 2\,(\dot{P}b, \dot{A}g)^8\,\dddot{S}b$. R.
461	Polybasite	$(\dot{A}g, \dot{C}u)^9\,\dddot{S}b$.
455	Fahlore (Antimony-F.)*	$(\dot{F}e, \dot{Z}n)^4\,\dddot{S}b + 2\,(\dot{C}u, \dot{A}g)^4\,\dddot{S}b$.

[1] From the isomorphism of the two sulphurets properly belongs to 1.

* The minerals marked with a star (*), in consequence of the isomorphism of their components, occur in several parts of the system.

455 White Fahlore ..... $(\dot{F}e, \dot{Z}n, \dot{C}u)^4 \dddot{S}b + (\dot{P}b, \dot{A}g)^4 \dddot{S}b$.

404 Mispickel..... } $\ddot{F}e + Fe\ As$.
404 (Plinian. Brthpt.) ... }

403 Leucopyrite ..... $\ddot{N}i + Ni\ As$, or $Ni\ (S, As)$.

410 Amoibite ..... $Ni^4\ (S^3, As^3)$.

405 Cobaltine..... $\ddot{C}o + Co\ As$, or $Co\ (S, As)$.

406 Smaltine ..... $(\ddot{F}e, \ddot{C}o) + (Fe, Co)\ As$, or $(Co, Fe)\ (S, As)$.

447 Gotthardtite ..... $\dot{P}b^2, \dddot{A}s$.

456 Copper blende ..... $(\dot{C}u, \dot{Z}n, \dot{F}e)^4 \dddot{A}s$.

456 Tennantite ..... $(\dot{F}e, \dot{C}u)^4 \dddot{A}s + 2\ \dot{C}u^4 \dddot{A}s$.

455 Fahlore (Arsenic F.)* $(\dot{F}e, \dot{Z}n)^4 \dddot{A}s + 2\ \dot{C}u^4 \dddot{A}s$.

471 Pyrargyrite, pale* ..... $\dot{A}g^3 \dddot{A}s$.

473 Xanthokon ..... $\dot{A}g^3 \dddot{A}s + 2\ \dot{A}g^3 \dddot{A}s$.

444 Geokronite* ..... $\dot{P}b^5\ (\dddot{S}b, \dddot{A}s)$.

443 Boulangerite ..... Pb, Sb, As, S.

458 Wölchite ..... Pb, Cu, Sb, As, S.

455 Fahlore (Antimony-Arsenic-Fahlore)* ..... $\dot{R}^4\ (\dddot{S}b, \dddot{A}s) + 2\ \dot{C}u^4\ (\dddot{S}b, \dddot{A}s)$.

3. Combinations of Sulphurets and Tellurets.

437 Tetradymite.

a) From Schemnitz ... $\dddot{B}i + 2\ Bi\ Te^3$.

b) From Brazil ..... $\dddot{B}i + 3\ Bi\ Te$.

D. *Oxides.*

91 Brucite (Hydrate of Magnesia) ..... $\dot{M}g\ \dot{H}$.

163 Corundum ..... $\ddot{A}l$.

155 Diaspore ..... $\ddot{A}l\ \dot{H}$.

156 Hydrargyllite ..... $\ddot{A}\cdot\dot{H}^3$.

161 Spinel ..... $\dot{M}g\ \ddot{A}l$.

	Völknerite. Herm.....	$\dot{M}g^6\,\ddot{A}l + 15\,\dot{H}$.
164	Chrysoberyl	$\dot{B}e\,\ddot{A}l$.
354*a*	Pechurane	$\dot{U}\,\ddot{U}$.
371	Uranum-ochre.....	$\ddot{U}$, $\dot{H}$.
359	Hausmannite	$\dot{M}n\,\ddot{M}n$.
360	Braunite	$\ddot{M}n$.
358	Manganite	$\ddot{M}n\,\dot{H}$.
357	Polianite	$\dot{M}n$
356	Pyrolusite	
365	Groroilite.....	$\dot{M}n\,\dot{H}$. (?)
361	Psilomelane.....	$\dot{M}n\,\dot{M}n^2 + \dot{H}$ or $3\,\dot{H}$ ($\dot{M}n$, partly replaced by $\dot{K}$, $\dot{B}a$, $\dot{M}g$, $\dot{C}u$, $\dot{C}o$).
365	Wad.....	
335	Magnetite	$\dot{F}e\,\ddot{F}e$.
338	Haematite	$\ddot{F}e$.
	Specular iron	
	Brown iron ore.	
341	*a*) Gotheite, &c.....	$\ddot{F}e\,\dot{H}$.
340	*b*) Limonite, &c.....	$\ddot{F}e^2\,\dot{H}^3$.
341	*c*) Turgite	$\ddot{F}e^2\,\dot{H}$. (?)
157	Periclase	$\dot{M}g$ ($\dot{F}e$).
161	Pleonaste.....	($\dot{M}g$, $\dot{F}e$) $\ddot{A}l$.
161	Chlorospinel	$\dot{M}g$ ($\ddot{A}l\,\ddot{F}e$).
379	Zincite.....	$\dot{Z}n$. (?)
162	Automalite	($\dot{Z}n$, $\dot{F}e$) $\ddot{A}l$.
337	Franklinite (Dysluite)	($\dot{Z}n$, $\dot{F}e$, $\dot{M}n$) ($\ddot{F}e$, $\ddot{M}n$).
344	Cassiterite	$\ddot{S}n$.
373	Lead-ochre	$\dot{P}b$.
372	Minium	$\dot{P}b\,\ddot{P}b$ or $\dot{P}b^2\,\ddot{P}b$.
355	Plattnerite	$\ddot{P}b$.
368	Bismuth-ochre	$\ddot{B}i$.
376	Cuprite	$\dot{C}u$.

378	Tenorite	$\dot{C}u$.
363	Cupreous Manganese	$(\dot{M}n, \dot{C}u)\,\ddot{M}n^2 + 2\,\dot{H}$.
364	Earthy Cobalt	$(\dot{C}o, \dot{C}u)\,\ddot{M}n^2 + 4\,\dot{H}$.
1	Quartz	$\ddot{S}i$.
1	Haytorite	
2	Opal	$\ddot{S}i, \dot{H}$.
251	Sassoline	$\ddot{B}\,\dot{H}^3$.
	Titanic acid	$\ddot{T}i$.
353	*a*) Rutile.	
352	*b*) Brookite.	
354	*c*) Anatase.	
370	Tungsten ochre	$\ddot{W}$.
367	Molybdena ochre	$\ddot{M}o$.
336	Chromite	$(\dot{F}e, \dot{M}g)\,(\ddot{C}r, \ddot{A}l)$.
339	Iute	$(\dot{I}r, \dot{O}s, \dot{F}e)\,(\ddot{I}r, \ddot{O}s, \ddot{C}r)$. (?)
375	Tellurite	$\ddot{T}e$.
380	Valentinite	$\ddot{S}b$.
369	Antimony ochre	$\ddot{S}b\,\ddot{S}b, \dot{H}$. Perhaps also $\ddot{S}b, \dot{H}$.
381	Arsenite	$\ddot{A}s$.

E. *Oxysulphurets.*

420	Voltzine	$\dot{Z}n\,\acute{Z}n^4$.
449	Kermes	$\ddot{S}b\,\overset{'''}{S}b^2$.

IV. *Combinations of Elements with bases of Salts* (*Salzbildnern*).

A. *Iodine compounds.*

331	Coccinite	Hg **I**. (?)
330	Iodite	Ag **I**.

B. *Bromine compounds.*

332	Bromite	Ag **Br**.

C. *Chlorine compounds.*

233 Rock salt..... Na Cl.
256 Sal-ammoniac..... NH^4 Cl.
316 Cotunnite ..... Pb Cl.
315 Mendipite ..... Pb Cl + 2 Ṗb.
295 Atacamite ..... (Cu Cl + 3 Ċu) + 3 Ḣ and 6 Ḣ.
329 Calomel ..... Hg Cl.
328 Kerate ..... Ag Cl.

D. *Fluorine compounds.*

205 Fluor spar ..... Ca Fl.
209 Cryolite ..... 3 Na Fl + Al Fl^3.
210 Chiolite ..... 3 Na Fl + 2 Al Fl^3. Herm. or
2 Na Fl + Al Fl^3. Chodn.
206 Yttracerite ..... Ca Fl, Ce Fl, Y Fl.
207 Fluocerite.
207 *a*) neutral ..... Ce Fl, Ce Fl^3.
208 *b*) basic (Fluocerine) Ce Fl^3 + 3 C̈e Ḣ.

V. *Combinations of electro-positive Oxides (Bases) with electro-negative Oxides (Acids). Oxygen salts.*

I. *Siliceous-acid Salts (Silicates).*

1. Silicates of Lime.

58 Okenite ..... Ċa³ S̈i⁴ + 6 Ḣ
Trisilicate of Lime from Gjellebäck Ċa S̈i.
108 Wollastonite ..... Ċa³ S̈i².

2. Silicates of Lime and Alkali.

59 Pectolite ..... [3 (Ṅa, K̇) S̈i + 4 Ċa³ S̈i²] + 3 Ḣ.

3. Silicates of Magnesia.

76 Steatite ..... Ṁg S̈i. Berzelius. Lychnell. Or
6 Ṁg S̈i + 4 Ṁg³ S̈i². R.

76 Talk ..... $3\dot{M}g\ddot{S}i + \dot{M}g^3\ddot{S}i^2$. R.

140 Meerschaum ... $\dot{M}g\ddot{S}i + \dot{H}$, or $2\dot{H}$.

140 Aphrodite ..... $\dot{M}g^3\ddot{S}i^2 + 2\dot{H} = (2\dot{M}g\ddot{S}i + \dot{H}) + \dot{M}g\dot{H}$.

84 Gymnite ..... $\dot{M}g^2\ddot{S}i + 3\dot{H} = (\dot{M}g\ddot{S}i + 2\dot{H}) + \dot{M}g\dot{H}$.

83 Spadaite ..... $\dot{M}g^5\ddot{S}i^4 + 4\dot{H} = (4\dot{M}g\ddot{S}i + 3\dot{H}) + \dot{M}g\dot{H}$.

81 Picrosmine ..... $2\dot{M}g^3\ddot{S}i^2 + 3\dot{H} = (4\dot{M}g\ddot{S}i + \dot{H}) + 2\dot{M}g\dot{H}$.

136 Kerolite ..... $\dot{M}g, \ddot{S}i, \dot{H}$.

(S. also 19. Alumina-Magnesia-Silicates.)

4. Silicates of Magnesia and Alkali.

143 Retinalite ..... $(2\dot{N}a\ddot{S}i + \dot{M}g^3\ddot{S}i) + 8\dot{H}$.

5. Silicates of Magnesia and Lime.

101 Augite..... $\dot{C}a^3\ddot{S}i^2 + \dot{M}g^3\ddot{S}i^2$. Comp. 30, 31, 32, 40, 46.
(Diopside, Malacolite.)

100 Hornblende..... $\dot{C}a\ddot{S}i + \dot{M}g^3\ddot{S}i^2$, perhaps also $3\dot{R}\ddot{S}i + 2\dot{R}^3\ddot{S}i^2$. Comp. 29, 31, 33, 40.
(Tremolite, Grammatite, Actinolite, Asbestus in part.)

29 Nephrite ..... $\dot{C}a, \dot{M}g, \ddot{S}i$.

6. Silicate of Glucina.

170 Phenakite ..... $\dot{B}e^3\ddot{S}i$

7. Silicates of Alumina.

137 Agalmatolite* ..... $\ddot{A}l\ddot{S}i^3$. Lychnell. Comp 8.

96 Pyrophyllite* ..... $\ddot{A}l\ddot{S}i^3 + 3\dot{H}$ (?). R. Comp. 19.

141 Razoumoffskin ... $\ddot{A}l\ddot{S}i^2 + 3\dot{H}$

151 Xenolite ..... $\ddot{A}l\ddot{S}i$.

98 Pholerite..... $\ddot{A}l\ddot{S}i + 2\dot{H}$.

152 Bamlite ..... $\ddot{A}l^2\ddot{S}i^3$.

153 Andalusite ..... $\ddot{A}l^4\ddot{S}i^3$.
(Bucholzite, Fibrolite.)

150 Cyanite ..... $\ddot{A}\dddot{l}^3\dddot{S}i^2$.
151 (Sillimanite.)
151 Wörthite ..... $\ddot{A}\dddot{l}^6\dddot{S}i^5 + 3\dot{H} = 5\ddot{A}\dddot{l}\dddot{S}i + \ddot{A}\dddot{l}\dot{H}^3$.
128 Allophane ..... $\ddot{A}\dddot{l}^3\dddot{S}i^2 + 15\dot{H}$ and $20\dot{H}$.
129 Opaline-Allophane $(\ddot{A}\dddot{l}^2\ddot{S}i + 12\dot{H}) + 2\ddot{A}\dddot{l}\dot{H}^3$.
120 Kaolin.
a) common..... $\ddot{A}\dddot{l}^3\ddot{S}i^4 + 6\dot{H}$, Forchhammer, or $\ddot{A}\dddot{l}\ddot{S}i + 2\dot{H}$, mixed with $\ddot{S}i$. Brongn. Malaguti.
b) from Passau $\ddot{A}\dddot{l}^2\ddot{S}i^3 + 6\dot{H}$.

131 Bole, in part .....
139 Catlinite .....
137 Cimolite .....
133 Collyrite .....
126 Halloysite ..... } $\ddot{A}\dddot{l}, \ddot{S}i, \dot{H}$.
126 Lenzinite.....
178 Nontronite .....
134 Lithomarge.....
126 Tuesite .....

8. Silicates of Alumina and Potash.

3 Potash-Felspar ... $\dot{K}\ddot{S}i + \ddot{A}\dddot{l}\ddot{S}i^3$.
(Orthoclase.)
39 Leucite ..... $\dot{K}^3\ddot{S}i^2 + 3\ddot{A}\dddot{l}\ddot{S}i^2$.
50 Damourite ..... $(\dot{K}\ddot{S}i + 3\ddot{A}\dddot{l}\ddot{S}i) + 2\dot{H} = (\dot{K}\ddot{S}i + \ddot{A}\dddot{l}\ddot{S}i^3) + 2\ddot{A}\dddot{l}\dot{H}$.
137 Agalmatolite*..... $\ddot{A}\dddot{l}, \dot{K}$ (Ca), $\ddot{S}i, \dot{H}$. Comp. 7.

9. Silicates of Alumina and Soda.

5 Soda-Felspar ..... $\dot{N}a\ddot{S}i + \ddot{A}\dddot{l}\ddot{S}i^3$.
(Albite.)
48 Mesotype ..... $(\dot{N}a\ddot{S}i + \ddot{A}\dddot{l}\ddot{S}i) + 2\dot{H}$.
(Natrolite.)

49 Lehuntite ..... $(\dot{N}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i) + 3\,\dot{H}$.

47 Analcime..... $(\dot{N}a^3\,\ddot{S}i^2 + 3\,\ddot{A}l\,\ddot{S}i^2) + 6\,\dot{H}$.

10. Silicates of Alumina, Soda, and Potash.

5 Potash-Soda-Felspar. (Pericline in part, Albite in part.) .....
3 Glassy Felspar ... } $(\dot{K}, \dot{N}a)\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^3$ and $(\dot{N}a, \dot{K})\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^3$.

4 Ryacolite ..... $(\dot{N}a, \dot{K})\,\ddot{S}i + \ddot{A}l\,\ddot{S}i$.

23 Nepheline (Elæolite)..... $(\dot{N}a, \dot{K})^2\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i$.

15 Pollux. Brthpt. $\dot{K}, \dot{N}a, \ddot{S}i, \dot{H}$.

11. Silicates of Alumina and Lithia.

14 Kastor. Brthpt. $\dot{L}i\,\ddot{S}i^3 + 2\,\ddot{A}l\,\ddot{S}i^3$.

A. Zygadite. Br. ... $\dot{L}i, \ddot{A}l, \ddot{S}i$.

12. Silicates of Alumina, Lithia and Soda.

12 Petalite ..... $(\dot{L}i, \dot{N}a)^3\,\ddot{S}i^4 + 4\,\ddot{A}l\,\ddot{S}i^4$.

13 Spodumene..... $(\dot{L}i, \dot{N}a)^3\,\ddot{S}i^4 + 4\,\ddot{A}l\,\ddot{S}i^2$.

13. Silicates of Alumina and Baryta.

62 Harmotome ..... $(\dot{B}a^3\,\ddot{S}i^2 + 4\,\ddot{A}l\,\ddot{S}i^2) + 18\,\dot{H}$. v. Kob.

14. Silicates of Alumina, Baryta and Strontia.

55 Brewsterite..... $[(\dot{S}r, \dot{B}a)\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^3] + 5\,\dot{H}$.

15. Silicates of Alumina and Lime.

54 Beaumontite ..... $(\dot{R}\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i^3) + 5\,\dot{H}$.

53 Aedelforsite ..... $(\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^3) + 4\,\dot{H}$.

52 Stilbite ..... $(\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^3) + 6\,\dot{H}$.

54 Heulandite ..... $(3\,\dot{C}a\,\ddot{S}i + 4\,\ddot{A}l\,\ddot{S}i^3) + 18\,\dot{H}$ or $21\,\dot{H}$.

66 Leonhardite ... $(3\,\dot{C}a\,\ddot{S}i + 4\,\ddot{A}l\,\ddot{S}i^2) + 15\,\dot{H}$.

60 Phacolite..... $(2\,\dot{C}a\,\ddot{S}i + \ddot{A}l^2\,\ddot{S}i^3) + 10\,\dot{H}$.

49 Scolezite ..... $(\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i)_4 + 3\,\dot{H}$.

49 Caporcianite ... $(\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i) + 3\,\dot{H}$ (?).

49 Poonahlite ..... $(3\,\dot{C}a\,\ddot{S}i + 5\,\ddot{A}l\,\ddot{S}i) + 12\,\dot{H} =$ $\left\{\begin{array}{l}(\dot{C}a\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i) + 6\,\dot{H} \\ (2\,\dot{C}a\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i) + 6\,\dot{H}\end{array}\right\}$

80 Chabazite ..... $(\dot{C}a^3\,\ddot{S}i^2 + 3\,\ddot{A}l\,\ddot{S}i^2) + 18\,\dot{H}$ and
$(\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^2) + 6\,\dot{H}$.

65 Laumontite..... $(\dot{C}a^3\ddot{S}i^2 + 4\ddot{A}l\,\ddot{S}i^2) + 18\,\dot{H}$, or perhaps
$(\dot{C}a^3\,\ddot{S}i^2 + 3\,\ddot{A}l\,\ddot{S}i^5) + 12\,\dot{H}$.

19 Barsowite ..... $\dot{C}a^3\,\ddot{S}i^2 + 3\,\ddot{A}l\,\ddot{S}i$.

67 Glottalite ..... $(\dot{C}a^3\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i) + 9\,\dot{H}$.

17 Meionite ..... $\dot{C}a^3\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i$.

17 Wernerite ..... $\dot{C}a^3\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i$.

10 Anorthite ..... $\dot{C}a^3\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i$.

84 Zeagonite ..... $(3\,\dot{R}\,\ddot{S}i + 4\,\ddot{A}l\,\ddot{S}i) + 15\,\dot{H}$.
(Gismondine)

B. Alumocalcite ...
68 Edingtonite.....
52 Sphærostilbite...
52 Hypostilbite ... $\dot{C}a,\ \ddot{A}l,\ \ddot{S}i,\ \dot{H}$.

16. Silicates of Alumina, Lime, and Potash.

49 Antrimolite..... $(3\,\dot{R}\,\ddot{S}i + \mathring{5}\,\ddot{A}l\,\ddot{S}i) + 15\,\dot{H}$. Perhaps
$(\dot{R}\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i) + 5\,\dot{H}$. R.

(99) Polyargite ..... $(\dot{R}^3\,\ddot{S}i^2 + 5\,\ddot{A}l\,\ddot{S}i) + 4\,\dot{H}$.

17. Silicates of Alumina, Lime, and Soda.

61 Faujasite..... $(\dot{R}^3\,\ddot{S}i^4 + 3\,\ddot{A}l\,\ddot{S}i^2) + 24\,\dot{H}$.

56 Epistilbite ..... $(\dot{R}\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i^3) + 5\,\dot{H}$.

11 Oligoclase ..... (Hafnefjordite, Loxoclase) $\dot{R}\,\ddot{S}i + \dot{A}\ddot{l}\,\ddot{S}i^2$.

8 Labradorite ... $\dot{R}\,\ddot{S}i + \dot{A}\ddot{l}\,\ddot{S}i$.

49 Mesolite.

a) Soda-Scolezite ... $[(\dot{C}a, \dot{N}a)\,\ddot{S}i + \dot{A}\ddot{l}\,\ddot{S}i] + 3\,\dot{H}$.

b) Lime-Mesotype ... $[(\dot{N}a, \dot{C}a)\,\ddot{S}i + \dot{A}\ddot{l}\,\ddot{S}i] + 2\,\dot{H}$.

(Harringtonite?).

40 Porcelain-Spar $\left\{\begin{array}{l}\dot{N}a\,\ddot{S}i + \dot{A}\ddot{l}\,\ddot{S}i. \\ \dot{C}a^3\,\ddot{S}i^2 + 2\,\dot{A}\ddot{l}\,\ddot{S}i.\end{array}\right\}$

6 Andesin ..... $\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i^2$.

7 Saccharite ..... $2\,(\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i^2) + 3\,\dot{H}$.

60 Lederite ..... $(\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i^2) + 6\,\dot{H}$.

60 Gmelinite ..... $(\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i^2) + 18\,\dot{H}$.

17 Scapolite ..... $\dot{R}^3\,\ddot{S}i^2 + 2\,\dot{A}\ddot{l}\,\ddot{S}i$.

49 Brevicite ..... $(\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i) + 6\,\dot{H}$.

49 Mesole ..... $(\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i) + 8\,\dot{H}$. ?

47 Sarcolite ..... $\dot{R}^3\,\ddot{S}i + \dot{A}\ddot{l}\,\ddot{S}i$.

10 Indianite ..... $\dot{R}^3\,\ddot{S}i + 3\,\dot{A}\ddot{l}\,\ddot{S}i$.

51 Thomsonite..... 51 Comptonite..... $(\dot{R}^3\,\ddot{S}i + 3\,\dot{A}\ddot{l}\,\ddot{S}i) + 7\,\dot{H}$.

18. Silicates of Alumina, Lime, Soda, and Potash.

63 Phillipsite ..... $(\dot{R}^3\ddot{S}i^2 + 3\,\dot{A}\ddot{l}\,\ddot{S}i^2) + 15\,\dot{H}$. R.

19. Silicates of Alumina and Magnesia.

138 Soapstone .....*a*) $(2\,\dot{M}g^3\,\ddot{S}i^2 + \dot{A}\ddot{l}\,\ddot{S}i) + 6\,\dot{H}$ and $10\,\dot{H}$.

(Saponite) ...*b*) $\left\{\begin{array}{l}(3\,\dot{M}g^3\,\ddot{S}i + 2\,\dot{A}\ddot{l}\,\ddot{S}i) + 3\,\dot{H}. \\ 4\,[(\dot{M}g^3\,\ddot{S}i^2) + 3\,\dot{H}].\end{array}\right.$

96 Pyrophyllite* ... $(\dot{M}g^3\,\ddot{S}i^2 + 9\,\dot{A}\ddot{l}\,\ddot{S}i^2) + 9\,\dot{H}$. ? Comp. 7.

87 Kämmererite ... $(2\,\dot{M}g^3\,\ddot{S}i + \ddot{A}l\,\ddot{S}i) + 6\,\dot{H}$.
86 (Pyrosklerite.)
. Steatite from Ural $(\dot{M}g^3\,\ddot{S}i\,\ddot{A}l^2\,\ddot{S}i) + 3\,\dot{M}g\,\dot{H}^2$. Herm.
C. Perthite ..... $\ddot{A}l, \dot{M}g, \ddot{S}i$.
136 Kerolite ..... $\ddot{A}l, \dot{M}g, \ddot{S}i\,\dot{H}$. *Comp. 3.

20. Silicates of Alumina, Magnesia, and Potash.

28*e* Onkosin ..... $\ddot{A}l, \dot{M}g, \dot{K}, \ddot{S}i, \dot{H}$.

21. Silicates of Alumina, Magnesia, and Lime.

28*d* Neurolite ..... $(\dot{R}^3\,\ddot{S}i^4 + 5\,\ddot{A}l\,\ddot{S}i^4) + 6\,\dot{H}$. (?)
10 Amphodelite ... $\dot{R}^3\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i$.
85 Chonikrite ..... $(3\,\dot{R}^3\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i) + 6\,\dot{H}$ (?), or perhaps $(\dot{R}^3\,\ddot{S}i^2 + \dot{R}\,\ddot{A}l) + 3\,\dot{H}$. (?)
113 Pyrallolite ..... $\dot{M}g, \dot{C}a, (\ddot{A}l)\,\ddot{S}i, \dot{H}$.

22. Silicates of Alumina, Magnesia, Lime, and Alkali.

99 Rosellan ..... $(\dot{R}^3\,\ddot{S}i^2 + 6\,\ddot{A}l\,\ddot{S}i) + 6\,\dot{H}$.
26 Humboldtilite... $2\,\dot{R}^3\,\ddot{S}i + \ddot{A}l\,\ddot{S}i$.
(Melilite.)
38 Diploite ..... $\dot{R}^3\,\ddot{S}i + 4\,\ddot{A}l\,\ddot{S}i$. (?)

23. Silicates of Alumina and Glucina.

169 Beryl. $\dot{B}e^3\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i^2$.
168 Euclase ..... $2\,\dot{B}e^3\,\ddot{S}i + \ddot{A}l^2\,\ddot{S}i$.

24. Silicates of Zirconia.

159 Zircon ..... $\ddot{Z}r\,\ddot{S}i$.
160 Malakon ..... $\ddot{Z}r_a\,\ddot{S}i$ or $\ddot{Z}r\,\ddot{S}i + \dot{H}$. (?)

25. Silicate of Thoria.

182 Thorite ..... Principally $= \dot{T}h^3\,\ddot{S}i + 3\,\dot{H}$.

26. Silicates of Manganese-proto(per)oxide [*oxydul*(*oxyd*)].

106	Tephroite	$\dot{M}n^3\,\ddot{S}i$.
360	Heterocline.....	$\dot{M}n^3\,\ddot{S}i$, mixed with $\ddot{M}n$ or $\dot{M}n$.
105	Manganese-silicate, black...	$\dot{M}n^3\,\ddot{S}i + 3\,\dot{H}$. (?)
360	Marceline	$\ddot{M}n^3\,\ddot{S}i$.
105	Silicate of Manganese.....	$\dot{M}n, \ddot{S}i$.

27. Silicate of Manganese-protoxide and Lime.

105	Manganese-silicate, red ..... (Bustamite.)	$\dot{R}^3\,\ddot{S}i^2$. Comp. 46.

28. Silicates of Iron-protoxide (and peroxide.)

181	Chlorophæite ... Anhydrous Silicate of Iron.	$\dot{F}e\,\ddot{S}i + 6\,\dot{H}$.
	Thoms.....	$\dot{F}e^3\,\ddot{S}i$.
39	Sideroschisolite	$\dot{F}e^6\,\ddot{S}i + 2\,\dot{H}$. (?)
177	Anthosiderite...	$\ddot{F}e\,\ddot{S}i^3 + \dot{H}$.
179	Pinguite	$(\dot{F}e\,\ddot{S}i + \ddot{F}e^2\,\ddot{S}i^3) + 15\,\dot{H}$.
D.	Thuringite	$(3\,\dot{F}e^3\,\ddot{S}i + \ddot{F}e^2\,\ddot{S}i) + 12\,\dot{H}$.
176	Hisingerite ..... (Thraulite.)	$(\dot{F}e\,\ddot{S}i + \ddot{F}e\,\ddot{S}i) + 6\,\dot{H}$ (?), or perhaps $\ddot{F}e\,\ddot{S}i + 3\,\dot{H}$. (?)

29. Silicates of Iron-proto(per)oxide and Soda.

112	Krokydolite ...	$(\dot{N}a^3\,\ddot{S}i^4 + 3\,\ddot{F}e^3\,\ddot{S}i^2) + x\,\dot{H}$.
100	Arfvedsonite*...	$\dot{N}a\,\ddot{S}i + \dot{F}e^3\,\ddot{S}i^2$. Comp. 5, 31, 33, 40.
110	Achmite	$\dot{N}a\,\ddot{S}i + \ddot{F}e\,\ddot{S}i^2$.

30. Silicates of Iron-proto(per)oxide and Lime.

116	Babingtonite ...	$2\,\dot{C}a\,\ddot{S}i + \dot{F}e^3\,\ddot{S}i^2$.

101 Augite* ..... $\dot{C}a^3\,\ddot{S}i^2 + \dot{F}e^3\,\ddot{S}i^2$. Comp. 5, 31, 32, 40, 46.

(Black A. from Arendal, Hedenbergite from Tunaberg.)

175 Wehrlite ..... $(\dot{F}e, \dot{C}a)^3\,\ddot{S}i + 3\,\dot{F}e\,\ddot{S}i$.

175 Lievrite ..... $3\,(\dot{C}a, \dot{F}e)^3\,\ddot{S}i + \dot{F}e^2\,\ddot{S}i$.

31. Silicates of Iron-proto(per)oxide and Magnesia.

100 Hornblende* ... (Anthophyllite, Asbestus in part.) $\dot{F}e\,\ddot{S}i + \dot{M}g^3\,\ddot{S}i^2$. Comp. 5, 29, 33, 40.

103 Bronzite* ..... (Hypersthene in part) ... $(\dot{M}g, \dot{F}e)^3\,\ddot{S}i^2$. Comp. Augite, 5, 30, 32, 40, 46.

81 Pycrophyll ..... $\dot{R}^3\,\ddot{S}i^2 + 2\,\dot{H}$.

142 Dermatine ..... $\dot{R}^3\,\ddot{S}i^2 + 6\,\dot{H}$. (?)

81 Monradite ..... $4\,\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{H}$.

79 Hydrophite ..... $\dot{R}^2\,\ddot{S}i + 3\,\dot{H}$. (?)

173 Olivine ..... (Hyalosiderite.) $(\dot{M}g, \dot{F}e)^3\,\ddot{S}i$.

82 Villarsite..... $4\,\dot{R}^3\,\ddot{S}i + 3\,\dot{H}$.

77 Schillerspar..... $(3\,\dot{R}\,\ddot{S}i + 2\,\dot{H}) + 2\,\dot{M}g\,\dot{H}$. R.

78 Antigorite ..... $\dot{R}^3\,\ddot{S}i^2 + \dot{M}g\,\dot{H}$.

80 Chrysotile ..... (Baltimorite, Schweitzer's Talksilicate.) $(\dot{R}^3\,\ddot{S}i^2 + 2\,\dot{H}) + \dot{M}g\,\dot{H}$.

80 Serpentine ..... $(2\,\dot{R}^3\,\ddot{S}i^2 + 3\,\dot{H}) + 3\,\dot{M}g\,\dot{H}$.

Magnesia-silicate (from Zermatt) ..... $2\,(\dot{R}^3\,\ddot{S}i^3 + 3\,\dot{H}) + 3\,\dot{M}g\,\dot{H}$.

93 Nemalite..... $(\dot{R}^3 \ddot{S}i + 6\,\dot{H}) + 6\,\dot{M}g\,\dot{H}$.

100 Rock-wood (from Sterzing) ... $3\,(\dot{M}g\,\ddot{S}i + \dot{H}) + (\ddot{F}e\,\ddot{S}i^2 + 2\,\dot{H})$.

32. Silicates of Iron-proto(per)oxide, Magnesia, and Lime.

101 Augite (Diopside, Sahlite, Malacolite, Diallage, Hypersthene, Asbestus in part)... $\dot{R}^3\,\ddot{S}i^2$, or more precisely partly $(\dot{C}a, \dot{F}e)^3\,\ddot{S}i^2 + \dot{M}g^3\,\ddot{S}i^2$, partly $\dot{C}a^3\,\ddot{S}i^2 + (\dot{M}g, \dot{F}e)^3\,\ddot{S}i^2$. Comp. 5, 30, 31, 40, 46.

173 Batrachite ..... $\dot{R}^3\,\ddot{S}i$.

100 Xylite ..... $(\dot{R}\,\ddot{S}i + \ddot{F}e\,\ddot{S}i) + \dot{H}$.

33. Silicates of Iron-protoxide, Magnesia, Lime, and Alkali.

100 Aegirine* ..... (Arfvedsonite.) $(\dot{N}a, \dot{K}, \dot{C}a, \dot{M}g)\,\ddot{S}i + \dot{F}e^3\,\ddot{S}i^3$. Comp. Hornblende, 5, 29, 31, 40.

34. Silicates of Iron-proto(per)oxide and Alumina.

131 Rhodalite (=Bole) $(\ddot{F}e, \ddot{A}l)\,\ddot{S}i^4 + 9\,\dot{H}$. (?)

154 Staurolite.

a) Fr. St Gotthardt ..... $\ddot{R}^2\,\ddot{S}i$.

b) Fr. Airolo $\ddot{R}^3\,\ddot{S}i^2$.

c) Fr. Brittany and Ural... $\ddot{R}^5\,\ddot{S}i^4$.

123 Erinite[1] ..... $(\ddot{A}l, \ddot{F}e)\,\ddot{S}i^2 + 6\,\dot{H}$.

132 Teratolite ..... $(\ddot{F}e, \ddot{A}l)^2\,\ddot{S}i^3 + 6\,\dot{H}$. (?)

90 Stilpnomelan ... $(2\,\dot{F}e^3\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i^2) + 6\,\dot{H}$.

144 Garnet* (Almandine) ..... $\dot{F}e^3\,\ddot{S}i + \ddot{A}l\,\ddot{S}i$. Comp. 36, 38, 40, 47; 49, 50, 51. XI.

73 Chloritoid* ..... $\dot{F}e^3\,\ddot{S}i + \ddot{A}l^3\,\ddot{S}i$. Erdm. Comp. 38.

[1] An Arseniate of Copper has the same name.

73	Sismondine	$\dot{F}e$ ($\ddot{F}e$), $\ddot{A}\dot{l}$, $\ddot{S}i$, $\dot{H}$.
122	Rock-soap	The same.
131	Bole in part.....	
E.	Chamoisite	
	Malthazite	

35. Silicates of Iron-proto(per)oxide, Alumina, and Alkali.

47	Cluthalite	$(\dot{R}^3 \ddot{S}i^2 + 3\ \ddot{A}\dot{l}\ \ddot{S}i^2) + 9\ \dot{H}$. (?)
72	Lepidomelan ...	$(Fe, \dot{K})^3\ \ddot{S}i + 3\ (\ddot{F}\dot{e}, \ddot{A}\dot{l})\ \ddot{S}i$.
F.	Iberite	$[(\dot{F}e, \dot{K})^3\ \ddot{S}i + 3\ \ddot{A}\dot{l}\ \ddot{S}i] + 3\ \dot{H}$.
121*e*	Pinite in part.* (From Stolpen, Pennig.)	$\ddot{A}\dot{l}$, $\dot{F}e$ ($\ddot{F}e$?) $\dot{K}$, $\ddot{S}i$, $\dot{H}$. Comp. 39.

36. Silicates of Iron-proto(per)oxide, Alumina, and Lime.

117	Isopyr	$2\ (\dot{C}a, \dot{F}e)\ \ddot{S}i + \ddot{A}\dot{l}\ \ddot{S}i^2$. R. (?)
		$\dot{C}a\ \ddot{S}i + (\ddot{A}\dot{l}, \ddot{F}\dot{e})\ \ddot{S}i$. von Kob. (?)
28	Huronite	$(\dot{R}^3 \ddot{S}i^2 + 4\ \ddot{A}\dot{l}\ \ddot{S}i) + 3\ \dot{H}$.
27	Prehnite	$(\dot{C}a^2\ \ddot{S}i + \ddot{R}\ \ddot{S}i) + \dot{H}$.
28	Kirwanite	$(3\ \dot{R}^2\ \ddot{S}i + \ddot{A}\dot{l}\ \ddot{S}i) + 2\ \dot{H}$.
G.	Diphanite	$(2\ \dot{R}^2\ \ddot{S}i + 3\ \ddot{A}\dot{l}^2\ \ddot{S}i) + 4\ \dot{H}$.
144	Garnet* ..... (Essonite, Grossulaire, Kancelstein, Romanzowite.)	$\dot{R}^3\ \ddot{S}i + \ddot{A}\dot{l}\ \ddot{S}i)$. Comp. 34, 38, 40, 47, 49, 50, 51. XI.
148	Epidote* ..... (Epidote and Pistacite.)	$\dot{R}^3\ \ddot{S}i + 2\ \ddot{R}\ \ddot{S}i$. Comp. 50.
148	Thulite	$\dot{R}^3\ \ddot{S}i + 2\ \ddot{A}\dot{l}\ \ddot{S}i$.
28	Zeuxite	$(\dot{R}^3\ \ddot{S}i + 2\ \ddot{R}\ \ddot{S}i) + 2\ \dot{H}$. (?)
25	Gehlenite	$2\ \dot{C}a^3\ \ddot{S}i + \ddot{R}^2\ \ddot{S}i$.

	Scorilite	$\dot{C}a$, $\ddot{A}l$, $\ddot{F}e$, $\ddot{S}i$.
123	Plinthite	$\dot{C}a$, $\ddot{A}l$, $\ddot{F}e$, $\ddot{S}i$, $\dot{H}$.

37. Silicates of Iron-proto(per)oxide, Alumina, Lime, and Alkali.

130	Chalilite	$(3\,\dot{R}\,\ddot{S}i + 4\,\ddot{R}\,\ddot{S}i) + 12\,\dot{H}$. (?)
19	Bytownite	$(\dot{C}a, \dot{N}a)^3\,\ddot{S}i^2 + 3\,(\ddot{A}l, \ddot{F}e)\,\ddot{S}i$.
18	Nuttalite	$3\,\dot{R}^2\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i$.
8	Saussurite	$\dot{N}a, \dot{C}a, \dot{F}e, \ddot{A}l, \ddot{S}i$.

38. Silicates of Iron-proto(per)oxide, Alumina, and Magnesia.

114	Pyrargillite	$(\dot{R}\,\ddot{S}i + \ddot{A}l\,\ddot{S}i) + 4\,\dot{H}$.
171	Cordierite ..... (Steinheilite, hard Fahlunite.)	$\dot{R}^3\,\ddot{S}i^2 + 3\,\ddot{R}\,\ddot{S}i$.
171*a*	Bonsdorffite ... (Metam. Cordierite.)	$(\dot{R}^3\,\ddot{S}i^2 + 3\,\ddot{R}\,\ddot{S}i) + 2\,\dot{H}$.
171*b*	Esmarkite ..... (Metam. Cordierite.)	$(\dot{R}^3\,\ddot{S}i^2 + 3\,\ddot{A}l\,\ddot{S}i) + 3\,\dot{H}$.
171*c*	Fahlunite ..... (Metam. Cordierite.)	$(\dot{R}^3\,\ddot{S}i^2 + 3\,\ddot{R}\,\ddot{S}i) + 6\,\dot{H}$.
144	Garnet..... .... (From Ohlapian, Hallandsas, etc.	$\dot{R}^3\,\ddot{S}i + \ddot{A}l\,\ddot{S}i$. Comp. 34, 36, 40, 47, 49, 50, 51. XI.
171*g*	Praseolite ..... (Metam. Cordierite.)	$(\dot{R}^3\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i) + 3\,\dot{H}$.
86	Pyrosklerite ...	$(2\,\dot{R}^3\,\ddot{S}i + \ddot{A}l\,\ddot{S}i) + 4\frac{1}{2}\,\dot{H}$. (?)
73	Chloritoid.* Bonsdorff.....	$(3\,\dot{R}^3\,\ddot{S}i + 2\,\ddot{A}l^3\,\ddot{S}i) + 6\,\dot{H}$. Comp. 34.

75 Chlorite (Pennine, Leuchtenbergite)...	$(\dot{M}g^3\ \ddot{S}i^2 + 3\ \ddot{\mathbf{R}}\ \ddot{S}i) + 9\ \dot{M}g\ \dot{\mathbf{H}}$. R.
74 Ripidolite	$(\dot{R}^3\ \ddot{S}i + 3\ \ddot{\mathbf{R}}\ \ddot{S}i) + 9\ \dot{M}g\ \dot{\mathbf{H}}$. R.
161 Saphirine.....	$3\ \dot{R}\ \ddot{\mathbf{A}}l + \ddot{\mathbf{A}}l\ \ddot{S}i$. (?)
158 Boltonite ..... Gedrite (= Hypersthene) ...	$\dot{M}g, \dot{F}e, \ddot{\mathbf{A}}l, \ddot{S}i$.
171 Aspasiolite ..... (Metam. Cordierite.) 76 Steatite* ..... 96 Vermiculite.....	$\dot{M}g, \dot{F}e, (\ddot{F}e), \ddot{\mathbf{A}}l, \ddot{S}i, \dot{\mathbf{H}}$.

39. Silicates of Iron-proto(per)oxide, Alumina, Magnesia, and Alkali.

71 Mica, mono-axial*	$(\dot{F}e, \dot{M}g, \dot{K})^3\ \ddot{S}i + (\ddot{F}e, \ddot{\mathbf{A}}l)\ \ddot{S}i$. Comp. 57.
171*e* Pinite in part* (From Auvergne.)	$(\dot{F}e, \dot{M}g, \dot{K})\ \ddot{S}i + \ddot{\mathbf{A}}l\ \ddot{S}i$. Comp. 35.
171*f* Gigantolite..... (Metam. Cordierite.)	$(\dot{R}\ \ddot{S}i + \ddot{\mathbf{A}}l\ \ddot{S}i) + \dot{\mathbf{H}}$,
171 Weissite ..... (Metam. Cordierite.)	$\dot{R}^3\ \ddot{S}i^2 + 2\ \ddot{\mathbf{A}}l\ \ddot{S}i^2$.
124 Greenearth ..... (In pt. metam. Augite.)	$\dot{F}e, \dot{M}g, \dot{K}, \ddot{\mathbf{A}}l, \ddot{S}i, \dot{\mathbf{H}}$.

40. Silicates of Iron-proto(per)oxide, Alumina, Magnesia and Lime.

101	Aluminous Augite* ..... (Diallage, Hypersthene in pt. Comp. 31, 32.)	$\dot{R}^3 (\ddot{S}i, \ddot{A}l)^2$. (?)
101	Aluminous Hornblendes	$\dot{R} (\ddot{S}i, \ddot{A}l) + \dot{R}^3 (\ddot{S}i, \ddot{A}l)^2$. (?)
94	Seybertite	$(\dot{R}\,\ddot{S}i + \dot{R}^3\,\ddot{A}l^2) + \dot{H}$. (?) Ob Xanthophyllite?
94	Xanthophyllite	$[3\,(\dot{R}\,\ddot{S}i + \dot{R}^3\,\ddot{A}l^2) + \dot{H}] + \ddot{A}l\,\dot{H}^3$. (?)
144	Garnet*	$\dot{R}^3\,\ddot{S}i + \ddot{R}\,\ddot{S}i$. Comp. 34, 36, 38, 47, 49, 50, 51, XI.
147	Vesuvian..... (Frugardite, Gökumite.)	Same Formula. $\dot{R}$ usually $= \dot{C}a$, $\dot{F}e$, sometimes also $\dot{M}g$, $\dot{M}n$, and $\dot{N}a$. — $\ddot{R} = \ddot{A}l$.
148	Puschkinite..... (Magnesia-Epidote.)	$\dot{R}^3\,\ddot{S}i + 2\,\ddot{R}\,\ddot{S}i$.
101	Jeffersonite, * Thomson.....	$3\,\dot{R}^3\,\ddot{S}i^2 + \ddot{A}l^2\,\ddot{S}i$. (?) Comp. 47.

41. Silicates of Iron-proto(per)oxide, Alumina, Magnesia, Lime and Alkali.

a) Containing Potash.

100	Raphilite.....	$6\,(\dot{C}a, \dot{M}g, \dot{K})\,\ddot{S}i + \ddot{R}\,\ddot{S}i$. (?)
119	Tachylite.....	$\dot{R}^3\,\ddot{S}i^2 + \ddot{A}l\,\ddot{S}i$.

b) Containing Soda.

158	Wychtine	$\dot{R}^3\,\ddot{S}i^2 + \ddot{R}\,\ddot{S}i^2$.
158	Glaucophane ...	$3\,\dot{R}^3\,\ddot{S}i^2 + 2\,\ddot{A}l\,\ddot{S}i^2$.

42. Silicates of Iron and Cerium-protoxide ($\dot{L}a$, $\dot{D}i$).

187	Cerite	$(\dot{C}e, \dot{L}a, \dot{D}i, \dot{F}e)^3\,\ddot{S}i + 3\,\dot{H}$.

43. Silicates of Iron and Cerium protoxides, Yttria (and Glucina.)

184 Gadolinite ..... $\dot{R}^3 \ddot{S}i$. (?)

44. Silicates of Iron protoxide, Cerium protoxide, Alumina and Lime.

185 Allanite ..... $3\,\dot{R}^3 \ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i$.

185 Cerine ..... $3\,\dot{R}^3 \ddot{S}i + 2\,\dddot{R}\,\ddot{S}i$.

45. Silicates of the former and of Yttria.

185 Orthite ..... $3\,\dot{R}^3 \ddot{S}i + 2\,\ddot{A}\dddot{l}\,\ddot{S}i$.

185 Pyrorthite ..... Orthite mixed with silicates of $\dot{C}e$, $\dot{Y}$, $\dot{M}n$, $\dot{F}e$, $\ddot{A}l$.

46. Silicates of Iron and Manganese proto(per)oxides.

105 Thomson's Silicate of Manganese from Franklin ... } $\dot{R}^3 \ddot{S}i^2$. Comp. 27.

105 Red Silicate of Manganese from Algiers }

107 Troostite..... $\dot{F}e^3 \ddot{S}i^2 + 3\,\dot{M}n^3 \ddot{S}i$.

173 Knebelite ..... $\dot{F}e^3 \ddot{S}i + \dot{M}n^3 \ddot{S}i$.

Siliceous-sinter from Freiberg $(\ddot{F}e, \ddot{M}n)^3 \ddot{S}i^2 + 18\,\dot{H}$.

173 Fowlerite ..... $\dot{M}n, \dot{F}e\,(\ddot{F}e?), \ddot{S}i, \dot{H}$.

47. Silicates of Iron proto(per)oxide, Manganese protoxide and Lime.

101 Jeffersonite,* Keating ..... $\dot{R}\,\ddot{S}i$. (?) Comp. 40.

144. Garnet* ..... (Ca, Mn)^3 Si + Fe Si. Comp. 34, 36, 38, 40, 49, 50, 51, XI.
(From Lindbo, Långbanshyttan, Altenau, Suhl, etc.)

48. Silicates of Iron and Manganese proto(per)oxides and Magnesia.

82 Villarsite..... 4 R^3 Si + 3 H.

89 Cronstedtite ... (Fe, Mn, Mg)^3 Si + Fe H^3.

49. Silicates of Iron and Manganese proto(per)oxides and Alumina.

20 Ottrelite ..... (R^3 Si^2 + 2 Al Si) + 3 H.

144 Garnet* ..... R^3 Si + Al Si. Comp. 34, 36, 38, 40, 47, 50, 51, XI.
(From Fahlun, Hungary, Engsö, Franklin, Broddbo.)

115 Karpholite ..... (R^3 Si + 3 Al Si) + 6 H. (?)

50. Silicates of Iron and Manganese proto(per)oxides, Alumina and Lime.

144 Garnet* ..... R^3 Si + R Si. Comp. 34, 36, 38, 40, 47, 49, 51, XI.
(White G. from Tellemark, brown from Klemetsaune, Hesselkulla, Arendal, Franklin, Vesuvius.)

148 Manganese-Epidote* ..... R^3 Si + 2 R Si. Comp. 36.

118 Polylite } ..... $\dot{F}e$, ($\ddot{F}e$?) $\dot{M}n$, $\dot{C}a$, $\ddot{A}l$, $\ddot{S}i$.
147 Xanthite }

51. Silicates of the above and of Magnesia.

144 Garnet* (Malsjö, Gotthardt, Wilui, Friedeberg, Arendal, Hallandsås.) $\dot{R}^3\,\ddot{S}i + \ddot{R}\,\ddot{S}i$. Comp. 34, 36, 38, 40, 47, 49, 50, XI.

Polyadelphite, [= Garnet] $\dot{R}$, $\ddot{R}$, $\ddot{S}i$.

52. Silicates of Nickel protoxide and Magnesia.

141 Pimelite ..... $2\,\dot{R}\,\ddot{S}i + \dot{H}$.

53. Silicates of Zinc oxide.

269 Williamite ..... $\dot{Z}n^3\,\ddot{S}i$.

268 Galmei ..... $2\,Zn^3\,\ddot{S}i + 3\,\dot{H}$, or $\dot{Z}n^3\,\ddot{S}i + 2\,\dot{H}$ (Thomson's and Hermann's An.)

54. Silicates of Copper protoxide.

278 Dioptase ..... $\dot{C}u^3\,\ddot{S}i^2 + 3\,\dot{H}$.

279 Chrysocolla..... $\dot{C}u^3\,\ddot{S}i^2 + 6\,\dot{H}$.

55. Silicates with Sulphurets.

146 Helvine ..... $\dot{M}n\,\dot{M}n + 3\,(\dot{M}n, \dot{F}e, \dot{B}e)^2\,\ddot{S}i$. (?)

56. Silicates with Chlorides.

41 Sodalite ..... $Na\,Cl + (Na^3\,\ddot{S}i + 3\,\ddot{A}l\,\ddot{S}i)$.

46 Eudialite..... $Na\,Cl + 4\,[2\,(\dot{C}a, \dot{N}a, \dot{F}e)^3\,\ddot{S}i^2 + \ddot{Z}r\,\ddot{S}i^2]$.

88 Pyrosmalite ... $(Fe\,Cl^3 + \ddot{F}e\,\dot{H}^6) + 4\,(\dot{F}e^3\,\ddot{S}i^2 + \dot{M}n^3\,\ddot{S}i^2)$. (?)

57. Silicates with Fluorides.

57 Apophyllite..... $\left.\begin{matrix}\dot{K}\,\ddot{S}i + 6\,\dot{C}a\,\ddot{S}i \\ K\,Fl + Si\,Fl^3 + 6(Ca\,Fl \\ + Si\,Fl^3)\end{matrix}\right\} + 15\,\dot{H}$. R.

167 Leucophane ... $2\,Na\,Fl + (2\,\dot{C}a^3\,\ddot{S}i^2 + 3\,\dot{B}e^2\,\ddot{S}i)$.

70 Lithia-mica.

a) Lepidolite ... $(K, Li, Na)\,Fl + (\ddot{A}l, \dot{M}n)\,\ddot{S}i^2$.

b) Lithia-mica $(K, Li, Na)\,Fl + (\ddot{A}l, \dot{F}e)\,\ddot{S}i^2$.

71 Mica, brown biaxial from N.York Mica* (1 and 2 axial). $K\,Fl + (3\,\dot{M}g^3\,\ddot{S}i + \ddot{A}l\,\ddot{S}i)$.

71 *a*) Magnesian... $\dot{K}, \dot{M}g, \dot{F}e\,(\dot{F}e), \ddot{A}l, \ddot{S}i, Fl$.

70 *b*) Non-magnes. $\dot{K}, \dot{F}e\,(\dot{F}e), \ddot{A}l, \ddot{S}i, Fl$. Comp. 39.

174 Chondrodite ... $Mg\,Fl + 2\,(\dot{M}g, \dot{F}e)^3\,\ddot{S}i$.

165 Topaz ..... $(Al\,Fl^3 + Si\,Fl^3) + 2(\ddot{A}l\,\ddot{S}i + \ddot{A}l^2\,\ddot{S}i)$. R.

166 Pycnite ..... $(Al\,Fl^3 + Si\,Fl^3) + 3\ddot{A}l\,\ddot{S}i + \ddot{A}l^2\,\ddot{S}i)$. R.

II. *Carbonates.*

246 Natron ..... $\dot{N}a\,\ddot{C} + x\,\dot{H}$.

248 Trona ..... $\dot{N}a^2\,\ddot{C}^3 + 4\,\dot{H}$.

221 Witherite ..... $\dot{B}a\,\ddot{C}$.

225 Strontianite ... $\dot{S}r\,\ddot{C}$.

204 Arragonite } ... $\dot{C}a\,\ddot{C}$.
199 Calc-spar }

249 Gay-Lussite ... $(\dot{N}a\,\ddot{C} + \dot{C}a\,\ddot{C}) + 5\,\dot{H}$.

223 Barytocalcite ... $\dot{B}a\,\ddot{C} + \dot{C}^a\,\ddot{C}$ and
$\dot{B}a\,\ddot{C} + 2\,\dot{C}a\,\ddot{C}$. (?)

202 Magnesite ..... $\dot{M}g\,\ddot{C}$.

92 Hydromagnesite $3\,(\dot{M}g\,\ddot{C} + \dot{H} + \dot{M}g\,\dot{H}$.

200 Bitterspar ..... $(\dot{C}a, \dot{M}g)\,\ddot{C}$.
(Dolomite, Guhrhofian, Miefnite)

200 Predazzite	$(2\,\dot{C}a\,\ddot{C} + \dot{M}g\,\ddot{C}) + \dot{H}$. (?)
H. Yttria-spar.....	$\dot{Y}, \ddot{C}$.
265 Lanthanite ..... (Carb. of cerium protox.)	$(\dot{L}a\,\ddot{C} + \dot{H}) + 2\,\dot{L}a\,\dot{H}$. (?)
261 Siderite ..... (Sphærosiderite.)	$[\dot{F}e, \dot{M}n, (\dot{M}g, \dot{C}a)]\,\ddot{C}$.
203 Mesitine-spar... (Ankerite, Breunnerite, Magnesite in pt.)	$(\dot{M}g, \dot{F}e)\,\ddot{C}$ and $(\dot{M}g, \dot{F}e, \dot{M}n, \dot{C}a)\,\ddot{C}$.
263 Diallogite 264 Manganocalcite	$(\dot{M}n, \dot{C}a, \dot{F}e, \dot{M}g)\,\ddot{C}$.
267 Calamine	$\dot{Z}n\,\ddot{C}$.
267 Zinc-bloom.....	$(\dot{Z}n\,\ddot{C} + \dot{H}) + 2\,\dot{Z}n\,\dot{H}$.
308 Cerussite.....	$\dot{P}b\,\ddot{C}$.
199 Plumbocalcite... 204 Lead-Arragonite	$(\dot{C}a, \dot{P}b)\,\ddot{C}$.
308 Zinc-lead-spar	$\dot{Z}n\,\ddot{C} + 6\,\dot{P}b\,\ddot{C}$.
281 Mysorine.....	$\dot{C}u^3\,\ddot{C}$.
281 Malachite	$\dot{C}u^2\,\ddot{C} + \dot{H}$ or $\dot{C}u\,\ddot{C} + \dot{C}u\,\dot{H}$.
280 Azurite	$\dot{C}u^3\,\ddot{C}^2 + \dot{H}$ or $2\,\dot{C}u\,\ddot{C} + \dot{C}u\,\dot{H}$.
282 Aurichalcite ...	$(\dot{Z}n^3\,\ddot{C} + 2\,\dot{H}) + (\dot{C}u^2\,\ddot{C} + \dot{H})$.
328 Silver-oxide, carbonate of? ...	$\dot{A}g\,\ddot{C}$. (?)

Carbonates with chlorides.

314 Phosgenite	$\dot{P}b\,\mathbf{Cl} + \dot{P}b\,\ddot{C}$.

Carbonates with Fluorides.

266 Parisite	Ce, La, Di, Ca, $\ddot{C}$, **Fl**, O, $\dot{H}$.

Carbonates with Silicates.

24 Cancrinite	$\dot{C}a\,\ddot{C} + (\dot{N}a^2\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i)$.
24 Stroganowite ...	$\dot{C}a\,\ddot{C} + [(\dot{C}a, \dot{N}a)^2\,\ddot{S}i + 2\,\ddot{A}l\,\ddot{S}i]$.

III. *Oxalates.*

506 Lime, oxalate of $\dot{C}a\,\ddot{C} + \dot{H}$. (?)

506 Oxalite ..... $2\,\dot{F}e\,\ddot{C} + 3\,\dot{H}$.
(Humboldtite.)

IV. *Mellitates.*

505 Mellite..... $(\ddot{A}l + 3\,C^4\,O^3) + 18\,\dot{H}$, or
$(\ddot{A}l + 3\,C^4\,H^2\,O^4) + 15\,\dot{H}$.

V. *Borates.*

250 Borax ..... $\dot{N}a\,\ddot{B}^2 + 10\,\dot{H}$.

I. Borocalcite ..... $\dot{C}a\,\ddot{B}^2 + 6\,\dot{H}$.

Hydroborocalcite $\dot{C}a, \ddot{B}, \dot{H}$.

216 Boracite ..... $\dot{M}g^3\,\ddot{B}^4$, or $\dot{M}g\,\ddot{B}^2 + 2\,\dot{M}g\,\ddot{B}$.

217 Hydroboracite $(\dot{C}a^3\,\ddot{B}^4 + \dot{M}g^3\,\ddot{B}^4) + 18\,\dot{H}$.

Borates with Silicates.

218 Datolite ..... $(3\,\dot{C}a\,\ddot{B} + \dot{C}a^3\,\ddot{S}i^4) + 3\,\dot{H}$. R.

$3\,(\dot{C}a\,\ddot{B} + \dot{C}a\,\ddot{S}i) + \dot{H}^3\,\ddot{S}i$. Scheerer.

218 Botryolite ..... $(3\,\dot{C}a\,\ddot{B} + \dot{C}a^3\,\ddot{S}i^4) + 6\,\dot{H}$. R.

$3\,(\dot{C}a\,\ddot{B} + \dot{C}a\,\ddot{S}i) + \dot{H}^6\,\ddot{S}i$. Scheerer.

149 Axinite ..... $(\dot{C}a, \dot{M}g)^3\,(\ddot{S}i, \ddot{B})^5$
$+ 2\,(\ddot{A}l, \ddot{F}e, \ddot{M}n)\,(\ddot{S}i, \ddot{B})$. R.

172 Tourmaline.

a) Schorl..... $\dot{R}\,(\ddot{B}, \ddot{C}) + \ddot{A}l\,\ddot{S}i^2$.
$\dot{R} = \dot{F}e, \dot{M}g, \dot{L}i, \dot{N}a$.

b) Achroite... $2\,\dot{R}\,(\ddot{B}, \ddot{C}) + 3\,\ddot{A}l^2\,\ddot{S}i^3$.
$\dot{R} = \dot{N}a, \dot{L}i, \dot{M}g, \dot{M}n$.

c) Rubellite... $2\,\dot{R}^2\,\ddot{B} + 3\,\ddot{A}l^2\,\ddot{S}i^3$.
$\dot{R} = \dot{N}a, \dot{L}i, \dot{M}n, \dot{M}g$.. Herm.

VI. *Combinations of Oxides of Titanium.*

a) Of Titanium oxide (Titanites).

342 Titanitic-iron ... $\dddot{Ti}$, $\dddot{Fe}$. H. Rose.

From Iserweise $\dddot{Ti} + \dddot{Fe}$.

- Egersund $\dddot{Ti}^2 + \dddot{Fe}^3$.
- Iserweise $\dddot{Ti}^3 + \dddot{Fe}^4$.
- Ilmen M. $\dddot{Ti}^4 + \dddot{Fe}^5$.
- Gastein ... $\dddot{Ti}^5 + \dddot{Fe}^4$.
- Arendal .. $\dddot{Ti} + \dddot{Fe}^3$.
- Spessart ... } $\dddot{Ti} + \dddot{Fe}^6$.
- Uddewalla }

b) Of Titanic acid (Titanates).

194 Perowskite ..... $\dot{Ca}\ \ddot{Ti}$.

192 Polymignite ... $\dot{Ca}, \dot{Y}, \dot{Ce}, \ddot{Zr}, \ddot{Fe}, \ddot{Mn}, \ddot{Ti}$.

195 Aeschynite, Hartwall ..... $\dot{Ce}, \dot{Ca}, \ddot{Zr}, \ddot{Fe}, \ddot{Ti}$. Comp. Tantalate with Titanaten.

Titanates with Silicates.

351 Sphene ..... $\dot{Ca}^3\ \ddot{Si} + \ddot{Ti}^3\ \ddot{Si}$. H. Rose.

(Greenovite) $2\ \dot{Ca}\ \ddot{Si} + \dot{Ca}\ \ddot{Ti}^3$. Berz.

190 Yttrotitanite ... (Keilhauite.) $[3\ \dot{Ca}^3\ \ddot{Si}^2 + (\ddot{Fe}, \ddot{Al})\ \ddot{Si}] + \dot{Y}\ \ddot{Ti}^3$. A. Erdm.

189 Oerstedtite ..... $\dot{Ca}, \dot{Mg}, \ddot{Zr}, \ddot{Ti}, \ddot{Si}, \dot{H}$.

K. Mosandrite ..... $\dot{La}, \dot{Ce}, \ddot{Mn}, \dot{Ca}, \dot{Mg}, \dot{K}, \ddot{Si}, \ddot{Ti}, \dot{H}$.

186 Tschewkinite ... $\dot{Ce}, \dot{La}, \dot{Di}, \dot{Fe}, \dot{Ca}\ (\dot{Mg}, \dot{Mn}, \dot{Be}, \dot{Y}, \ddot{Al})$, $\ddot{Si}, \ddot{Ti}$.

VII. *Tantalates (containing Niobium and Pelopium).*

350 Fergusonite ... $\dot{Y}, \dot{Ce}, \ddot{Zr}, Ta, O$.

346 Columbite	$\dot{F}e, \dot{M}n, (\ddot{S}n)\ Ta, O.$	
347 Tantalite.....		
348 Yttrotantalite...	$\dot{Y}, \dot{C}a, \ddot{F}e, \ddot{U}, W, Ta, O.$	
188 Pyrochlore.*		
(Microlite) from Miask	$\dot{N}a\ Fl + \dot{C}a, \dot{C}e, Th, Ta, O.$	Wöhler. Comp. Tantalates with Titanates.
Brevig.....	$\dot{C}a, \dot{C}e, \dot{T}h, \dot{U}, Ta\ O, \dot{H}.$	
198 Uranotantalite	$U, Ta, O.$	

Tantalates with Silicates.

191 Wöhlerite	$\dot{N}a, \dot{C}a, \ddot{Z}r, \ddot{F}e, \ddot{S}i, Ta, O.$

Tantalates with Titanates.

188 Pyrochlore,* from Miask	$\dot{K}, \dot{N}a, \dot{L}i, \dot{C}a, \dot{L}a, \ddot{C}e, \ddot{Z}r, \ddot{F}e, \ddot{T}i, Ta, O.$	Herm. Comp. Tantalates.
198 Yttroilmenite ...	$\dot{Y}, \dot{F}e, \dot{C}e, \dot{L}a, \ddot{T}i, Ta, O.$	Herm.
349 Euxenite.....	$\dot{Y}, \ddot{U}, \dot{C}e, \dot{C}a, \ddot{T}i, Ta, O, \dot{H}.$	
195 Aeschynite,* Hermann	$\dot{C}e, \dot{L}a, \dot{Y}, \dot{F}e, \ddot{Z}r\ (?), \ddot{T}i, Nb, O.$	Comp. Titanates.
193 Polykrase	$\dot{C}e, \dot{Y}, \ddot{Z}r, \ddot{U}, \ddot{F}e, \ddot{T}i, Ta, O.$	

VIII. *Tungstates.*

334 Scheelite	$\dot{C}a\ \ddot{W}$ and $(\dot{C}a, \dot{C}u)\ \ddot{W}.$
345 Wolfram.....	$(\dot{F}e, \dot{M}n)\ \ddot{W}.$
a) From Monte Video, Ehrenfriedersdorf, Limoges, Neudorf.	$\dot{M}n\ \ddot{W} + 4\ \dot{F}e\ \ddot{W}.$

	b) From Cumberland, Chantcloupe	$\dot{M}n\,\ddot{W} + 3\,\dot{F}e\,\ddot{W}$.
	c) From Zinnwald	$3\,\dot{M}n\,\ddot{W} + 2\,\dot{F}e\,\ddot{W}$.
322	Scheelitine	$\dot{P}b\,\ddot{W}$.

IX. *Molybdates.*

321	Wulfenite	$\dot{P}b\,\ddot{M}o$ and $(\dot{P}b, \dot{C}a)\,\ddot{M}o$.
321	Mineral from Pamplona ...	Chief constituent, $\dot{P}b^3\ddot{M}o$. Boussing. (?)

X. *Vanadiates.*

320	Vanadinite	$(\dot{P}b\,\mathbf{Cl} + 2\,\dot{P}b) + \dot{P}b^3\,\ddot{V}^2$. (?)
296	Volborthite	$\dot{C}u, \ddot{V}$.

XI. *Chromium-combinations.*

a) Of Chromium oxide.

374	Wolchonskoite	$(\ddot{C}r, \ddot{F}e, \ddot{A}l)^2\,\ddot{S}i^3 + 9\,\dot{H}$. (?)
374	Chrome-ochre...	$(\ddot{A}l, \ddot{C}r, \ddot{F}e)^8\,\ddot{S}i^4 + 6\,\dot{H}$. Wolff.
135	Miloschin	$(\ddot{A}l, \ddot{C}r)^3\,\ddot{S}i^2 + 9\,\dot{H}$.
144	Uwarowite*... (Chrome-garnet.)	$\dot{C}a^3\,\ddot{S}i + (\ddot{C}r, \ddot{A}l)\,\ddot{S}i$. Comp. Garnet under Silicates.
145	Pyrope	$\dot{M}g, \dot{C}a, \dot{F}e\,(\ddot{F}e), \ddot{A}l, \ddot{C}r, \ddot{S}i$.
69	Fuchsite, Chrome-mica	$\dot{K}, \dot{M}g, \ddot{A}l, \ddot{F}e, \ddot{C}r, \ddot{S}i$.

b) Of Chromic acid (Chromates).

324	Crocoisite	$\dot{P}b\,\ddot{C}r$.
325	Melanochroite...	$\dot{P}b^3\,\ddot{C}r^2$.
326	Vauquelinite ...	$\dot{C}u^3\,\ddot{C}r^2 + 2\,\dot{P}b^3\,\ddot{C}r^2$

XII. *Antimoniates.*

333 Romeïte ..... $\dot{Ca}, \dot{Mn}, \dot{Fe}, \ddot{Sb}, \ddot{Sb}$.

319 Bleimerite ..... $\dot{H}\ \dot{Pb}^3\ \ddot{Sb} + 4\ \dot{H}$.

Mineral from Chile ..... $\dot{Hg}, \ddot{Sb}, \ddot{Sb}$

XIII. *Arseniates.*

231 Haidingerite ..... $\dot{Ca}^2\ \ddot{As} + 4\ \dot{H}$. (?)

230 Pharmacolite ... $\dot{Ca}^2\ \ddot{As} + 6\ \dot{H}$.

230 Picropharmacolite $(\dot{Ca}, \dot{Mg})^6\ \ddot{As}^2 + 12\ \dot{H}$.

232 Berzeliite ..... $\dot{Ca}^3\ \ddot{As} + (\dot{Mg}, \dot{Mn})^3\ \ddot{As}$.

299 Scorodite ..... $\dot{Fe}\ \ddot{As} + 4\ \dot{H}$.

298 Pharmakosiderite $(\dot{Fe}^3\ \ddot{As} + \dot{Fe}^3\ \ddot{As}^2) + 18\ \dot{H}$. (?)
(Beudantite.)

299 Arseniosinter.

a) From Nertschinsk) ... $\dot{H}\dot{Fe}\ \ddot{As} + 4\ \dot{H}$.
(Amorphous Scorodite.)

b) White, from Freiberg ..... $\dot{Fe}^2\ \ddot{As} + 12\ \dot{H}$. Comp. Sulphates with Arseniates.

297 Arseniosiderite ..... $(2\ \dot{Ca}^3\ \ddot{As} + 3\ \dot{Fe}^2\ \ddot{As}) + 12\ \dot{H}$

307 Nickel-ochre ... $\dot{H}\ \dot{Ni}^3\ \ddot{As} + 8\ \dot{H}$.

306 Erythrine ..... $\dot{H}\ \dot{Co}^3\ \ddot{As} + 8\ \dot{H}$.

288 Euchroite ..... $\dot{H}\ (\dot{Cu}^2\ \ddot{As} + 6\ \dot{H}) + \dot{Cu}\ \dot{H}$.

283 Copper-mica ..... $\dot{H}\ [(\dot{Cu}, \dot{Fe})^6\ \ddot{As} + 18\ \dot{H}] + 5\ \dot{Cu}\ \dot{H}$.

XIV. *Phosphates.*

a) Pure Phosphates.

506 Struvite ..... $(\dot{Mg}^2, \dot{N}\dot{H}^4)\ \dot{P} + 12\ \dot{H}$.

[1] From its origin this compound properly does not belong to the mineral kingdom. (Comp. note, p. 525.)

215	Xenotime	$\dot{Y}^3\dddot{P}$.
156	Gibbsite	$\dot{Al}\dddot{P} + 8\dot{H}$. Herm.
31	Calaite	$(\dot{Al}^4\dddot{P}^3 + 9\dot{H}) + 2\dot{Al}\dot{H}^3$. (?)
31	Peganite	$(\dot{Al}^4\dddot{P}^3 + 12\dot{H}) + 2\dot{Al}\dot{H}^3$. Herm.
31	Fischerite	$(\dot{Al}^4\dddot{P}^3 + 18\dot{H}) + 2\dot{Al}\dot{H}^3$. Herm.
	Alumina, phosphate of, from Bourbon	$\dot{N}\dot{H}^4\dot{Al}, \dddot{P}, \dot{H}$.
30	Lazulite (Blauspath)	$[2(\dot{Mg}, \dot{Fe})^3\dddot{P} + \dot{Al}^4\dddot{P}^3] + 6\dot{H}$. R.
	L. Cryptolite	$\dot{Ce}, \dddot{P}$
197	Monazite (Edwardsite	$\dot{Ce}, \dot{La}, \dot{Th}, \dddot{P}$. Kersten. $(\dot{Ce}, \dot{La})^3\dddot{P}$. Hermann.
197	Monazitoid	$(\dot{Ce}, \dot{La})^5\dddot{P}$. Herm.
304	Uranite	$(\dot{Ca}^3\dddot{P} + 2\dot{U}^3\dddot{P}) + 24\dot{H}$.
303	Dufrénite	$2\dot{Fe}^2\dddot{P} + 5\dot{H}$.
277	Delvauxite	$\dot{Fe}^2\dddot{P} + 24\dot{H}$.
302	Vivianite.....	$6(\dot{Fe}^3\dddot{P} + 8\dot{H}) + (\dot{Fe}^3\dddot{P}^2 + 8\dot{H})$. R.
270	Triplite	$\dot{Fe}^4\dddot{P} + \dot{Mn}^4\dddot{P}$.
274	Heteposite	$(2\dot{Fe}^4\dddot{P}^3 + \dot{Mn}^5\dddot{P}^2) + 5\dot{H}$.
273	Hureaulite	$(\dot{Fe}^5\dddot{P}^2 + 3\dot{Mn}^5\dddot{P}^2) + 30\dot{H}$.
272	Triphyline	$\dot{Li}^3\dddot{P} + 6(\dot{Fe}, \dot{Mn})^3\dddot{P}$.
214	Childrenite	$\dot{Al}, \dot{Fe}, \dddot{P}$.
292	Libethenite.....	$\dot{Cu}^3\dddot{P} + \dot{Cu}\dot{H}$.
293	Tagilite	$(\dot{Cu}^3\dddot{P} + 2\dot{H}) + \dot{Cu}\dot{H}$.
290	Phosphorochalcite	$\dot{Cu}^3\dddot{P} + 2\dot{Cu}\dot{H}$ and $\dot{Cu}^3\dddot{P} + 3\dot{Cu}\dot{H}$.
294	Ehlite	$(\dot{Cu}^3\dddot{P} + \dot{H}) + 2\dot{Cu}\dot{H}$.
291	Thrombolite ...	$\dot{Cu}^3\dddot{P}^2 + 6\dot{H}$. (?)
305	Chalcolite	$(\dot{Cu}^3\dddot{P} + 2\dot{U}^3\dddot{P}) + 24\dot{H}$.

b Phosphates with Fluorides.

33	Wagnerite	$\dot{Mg}\dot{F}l + \dot{Mg}^3\dddot{P}$. R.

32 Wavellite ..... $\mathbf{Al\,Fl^3} + 3\,[(\dot{\ddot{A}}l^4\,\dot{\ddot{P}}^3) + 18\,\dot{H}]$. Berz.
$(\dot{A}l\,\mathbf{Fl^3} + 2\,\dot{\ddot{A}}l) + 6\,[(\dot{\ddot{A}}l^4\,\dot{\ddot{P}}^3) + 18\,\dot{H}]$. Herm.

34 Amblygonite ... $(R\,\mathbf{Fl} + Al\,\mathbf{Fl^3}) + (\dot{R}^5\,\dot{\ddot{P}}^3 + \dot{\ddot{A}}l^5\,\dot{\ddot{P}}^3)$. R.

271 Zwieselite ..... $Fe\,\mathbf{Fl} + 3\,(\dot{F}e, \dot{M}n)^3\,\dot{\ddot{P}}$.

317 Green-lead-ore* in part. (Pyromorphite.) $Pb\,\mathbf{Cl} + 3\,\dot{P}b^3\,\dot{\ddot{P}}$. Comp. *c*, *d*.

c) Phosphates with Chlorides and Fluorides.

212 Apatite ..... $Ca\,(\mathbf{Cl}, \mathbf{Fl}) + 3\,\dot{C}a^3\,\dot{\ddot{P}}$.

212 Magnesia-apatite $\dot{C}a, \dot{M}g, \dot{\ddot{P}}, \mathbf{Cl}, \mathbf{Fl}, \dot{\ddot{S}}$.

317 Green-lead-ore* in part. (Polysphærite.) $(Pb, Ca)\,(\mathbf{Cl}, \mathbf{Fl}) + 3\,(\dot{P}b, \dot{C}a)^3\,\dot{\ddot{P}}$. Comp. *b*, *d*.

323 Plombgomme ... $(Pb\,\mathbf{Cl} + 3\,\dot{P}b^3\,\dot{\ddot{P}}) + 18\,\dot{\ddot{A}}l\,\dot{H}^3$. (?)

d) Phosphates with Arseniates.

318 Green-lead-ore* in part.

a) Mimetesite $Pb\,\mathbf{Cl} + 3\,\dot{P}b^3\,(\dot{\ddot{P}}, \dot{\ddot{A}}s)$. Comp. *b*, *c*.

b) Hedyphane $Pb\,\mathbf{Cl} + 3\,(\dot{P}b, \dot{C}a)^3\,(\dot{\ddot{A}}s, \dot{\ddot{P}})$. (Hed. from Långbanshyttan.)

287 Olivenite..... $\dot{C}u^3\,(\dot{\ddot{A}}s, \dot{\ddot{P}}) + \dot{C}u\,\dot{H}$.

289 Strahlerz..... (Klinoclase, Aphanese.). $\dot{C}u^3\,(\dot{\ddot{A}}s, \dot{\ddot{P}}) + 3\,\dot{C}u\,\dot{H}$.

284 Tirolite ..... $(\dot{C}u^3\,(\dot{\ddot{A}}s, \dot{\ddot{P}}) + 8\,\dot{H}) + 2\,\dot{C}u\,\dot{H}$. (?)

285 Erinite..... $[\dot{C}u^3\,(\dot{\ddot{A}}s, \dot{\ddot{P}}) + 9\,\dot{H}] + 3\,\dot{C}u\,\dot{H}$.

286 Liroconite ..... $[\dot{C}u^3\,(\dot{\ddot{A}}s, \dot{\ddot{P}}) + 18\,\dot{H} + 5\,\dot{C}u\,\dot{H}] + [\dot{\ddot{A}}l^2\,(\dot{\ddot{A}}s, \dot{\ddot{P}}) + \dot{H}]$.

e) Phosphates and Arseniates with Chlorides.

317 Nussierite ..... $Pb\,\mathbf{Cl} + 5\,(\dot{P}b, \dot{C}a)^3\,(\dot{\ddot{P}}, \dot{\ddot{A}}s)$. (?)

f) Phosphates with Silicates.

111	Sordawalite.....	$\dot{F}e, \dot{M}g, \ddot{A}l, \ddot{S}i, \ddot{P}, \dot{H}$.
183	Eulytine	$2\,\dot{B}i^2\,\ddot{S}i^5 + \dot{B}i^2\,\ddot{P}$. (?)

XV. *Nitrates.*

252	Nitre	$\dot{K}\,\ddot{N}$.
253	Nitratine.....	$\dot{N}a\,\ddot{N}$.
254	Nitrocalcite.....	$\dot{C}a\,\ddot{N} + \dot{H}$.
329	Mercury, nitr. of	$\dot{H}g, \ddot{N}$. (?)

XVI. *Selenites.*

424	Clausthalite ...	$\dot{P}b, \ddot{S}e$.,

XVII. *Sulphates.*

a) Pure Sulphates.

259	Thenardite	$\dot{N}a\,\ddot{S}$.
236	Glaubersalt.....	$\dot{N}a\,\ddot{S} + 2\,\dot{H}$.
257	Mascagnine.....	$\dot{N}H^4\,\ddot{S}$.
219	Barytes	$\dot{B}a\,\ddot{S}$.
224	Celestine.....	$\dot{S}r\,\ddot{S}$.
	Strontbarytspath 224 Barytocelestine 220 (Dreelite?) ...	$(\dot{B}a, \dot{S}r)\,\ddot{S}$.
227	Anhydrite	$\dot{C}a\,\ddot{S}$.
226	Gypsum	$\dot{C}a\,\ddot{S} + 2\,\dot{H}$.
229	Glauberite	$\dot{N}a\,\ddot{S} + \dot{C}a\,\ddot{S}$.
260	Epsomite.....	$\dot{M}g\,\ddot{S} + 7\,\dot{H}$.
228	Polyhalite	$[(\dot{K}\,\ddot{S} + \dot{M}g\,\ddot{S}) + \dot{H}] + (2\,\dot{C}a\,\ddot{S} + \dot{H})$.
235	Alunogene	$\ddot{A}l\,\ddot{S}^3 + 18\,\dot{H}$.
	(Basic Sulphate of Alumina from Ararat.)	$\ddot{A}l\,\ddot{S}^2 + x\,\dot{H}$. (?)

30 Aluminite ..... $\ddot{A}l\,\ddot{S} + 9\,\dot{H}$, in part mixed with $\ddot{A}l\,\dot{H}$.

35 Alumstone ..... $(\dot{K}\,\ddot{S} + 3\,\ddot{A}l\,\ddot{S}) + 6\,\dot{H}$.

234 Potash-Alum ... $(\dot{K}\,\ddot{S} + \ddot{A}l\,\ddot{S}^3) + 24\,\dot{H}$.

234 Soda-Alum

a) Neutral... $(\dot{N}a\,\ddot{S} + \ddot{A}l\,\ddot{S}^3) + 24\,\dot{H}$.

b) Basic? $(2\,\dot{N}a\,\ddot{S} + 8\,\ddot{A}l\,\ddot{S}^2) + 10\,\dot{H}$. (?)

Perhaps Soda-alum mixed with $\ddot{A}l\,\ddot{S}^2 + 9\,\dot{H}$.

234 Ammonia-Alum $(\dot{N}H^4\,\ddot{S} + \ddot{A}l\,\ddot{S}^3) + 24\,\dot{H}$.

234 Magnesia-Alum (Pickeringite.) $(\dot{M}g\,\ddot{S} + \ddot{A}l\,\ddot{S}^3) + 22\,\dot{H}$. (?)

245 Uran-vitriol ... (Johannite.) $\ddot{U}\,(\ddot{U})^3\,\ddot{S}_3\,\dot{H}$.

234 Manganese-Alum ..... $(\dot{M}n\,\ddot{S} + \ddot{A}l\,\ddot{S}^3) + 24\,\dot{H}$.

234 Manganese-Magnesia-Alum $[(\dot{M}g, \dot{M}n)\,\ddot{S} + \ddot{A}l\,\ddot{S}^3] + 24\,\dot{H}$.

237 Melanterite..... $\dot{F}e\,\ddot{S} + 7\,\dot{H}$.

240 Coquimbite..... $\dot{F}e^2\,\ddot{S}^3 + 9\,\dot{H}$.

239 Foliated Copiapite ..... $\dot{F}e^2\,\ddot{S}^3 + 18\,\dot{H}$. (?)

239 Radiated Copiapite ..... $2\,\dot{F}e\,\ddot{S}^2 + 21\,\dot{H}$. (?)

239 Vitriol-ochre ... $\dot{F}e^2\,\ddot{S} + 6\,\dot{H}$.

239 Fibroferrite..... $\dot{F}e^3\,\ddot{S}^5 + 27\,\dot{H} = (2\,\dot{F}e\,\ddot{S}^2 + 21\,\dot{H}) + (\dot{F}e\,\ddot{S} + \dot{H})$. (?)

239 Apatelite..... $(2\,\dot{F}e^2\,\ddot{S}^3 + \dot{F}e\,\ddot{S}) + 3\,\dot{H}$. (?)

234 Iron-Alum ..... $[(\dot{F}e, \dot{M}g, \dot{K})\,\ddot{S} + (\ddot{A}l, \dot{F}e)\,\ddot{S}^3] + 24\,\dot{H}$.

234 Voltaite ..... $[3\,(\dot{F}e, \dot{K})\,\ddot{S} + 2\,(\dot{F}e, \ddot{A}l)\,\ddot{S}^3] + 12\,\dot{H}$.

239 Yellow iron ore

a) Containing Potash..... $(\dot{K}\,\ddot{S} + 4\,\dot{F}e\,\ddot{S}) + 9\,\dot{H}$.

b) Containing

	Soda	$(\dot{Na}\,\ddot{S} + 4\,\dot{Fe}\,\ddot{S}) + 9\,\dot{H}$.
237	Pissophane	$\dot{Fe}, \ddot{Al}, \ddot{S}, \dot{H}$.
238	Botryogene.....	$\dot{Fe}, Mg, \dot{Fe}, \ddot{S}, \dot{H}$.
244	Bieberite.....	$\dot{Co}^2\,\ddot{S} + 8\,\dot{H}$ (?) and
		$(\dot{Mg}\,\ddot{S} + 7\,\dot{H}) + 3\,(\dot{Co}\,\ddot{S} + 7\,\dot{H})$.
243	Goslarite.....	$\dot{Zn}\,\ddot{S} + 7\,\dot{H}$.
309	Anglesite.....	$\dot{Pb}\,\ddot{S}$.
242	Cyanose	$\dot{Cu}\,\ddot{S} + 5\,\dot{H}$.
301	Brochantite.....	$\dot{Cu}\,\ddot{S} + 3\,\dot{Cu}\,\dot{H}$.
313	Copper-lead vitriol	$\dot{Pb}\,\ddot{S} + \dot{Cu}\,\dot{H}$. (?)
	(Linarite.)	

b). Sulphates with Chlorides.

233	Martinsite	$\dot{Mg}\,\ddot{S} + 10\,\dot{Na}\,\dot{Cl}$. (?)

c) Sulphates with Fluorides.

	Baryt-fluor-spar	$\dot{Ba}\,\ddot{S} + 3\,\dot{Ca}\,\dot{Fl}$. (?)

d) Sulphates with Silicates.

43	Nosean	$\dot{Na}, \ddot{Al}, \ddot{Si}, \ddot{S}, \dot{Cl}$. (?)
42	Haüyne	$\dot{K}, \dot{Na}, \dot{Ca}, \ddot{Al}, \ddot{Si}, \ddot{S}, \dot{Cl}$.
45	Lapis Lazuli ...	
44	Ittnerite	

e) Sulphates with Carbonates.

	Calstrontbaryte	$\dot{Ba}\,\ddot{S} + (\dot{Sr}, \dot{Ca})\,\ddot{C}$. (?)
221	Barytes, sulpha-	
	to-carbonate of	$\dot{Ba}\,\ddot{S} + 2\,\dot{Ba}\,\ddot{C}$. (?)
311	Lanarkite	$\dot{Pb}\,\ddot{S} + \dot{Pb}\,\ddot{C}$.
310	Leadhillite.....	$\dot{Pb}\,\ddot{S} + 3\,\dot{Pb}\,\ddot{C}$.

312 Caledonite ..... $2\,(\dot{P}b\,\ddot{S} + \dot{P}b\,\ddot{C}) + (\dot{P}b\,\ddot{S} + \dot{C}u\,\ddot{C}$. (?)

327 Bismuthite ..... $\dot{B}i, \ddot{S}, \ddot{C}$.

f) Sulphates with Arseniates.

276 Iron sinter.*

a) From Freiberg..... $(\dot{F}e\,\ddot{S}^3 + 15\,\dot{H}) + (\dot{F}e^3\,\ddot{A}s^3 + 15\,\dot{H})$.

b) From Gastein ..... $3\,(\dot{F}e^2\,\ddot{S} + 5\,\dot{H}) + 5\,(\dot{F}e^2\,\ddot{A}s + 5\,\dot{H})$. Comp. Arseniates.

g) Sulphates with Phosphates.

277 Diadochite ..... $3\,(\dot{F}e\,\ddot{S} + 12\,\dot{H}) + (\dot{F}e^5\,\ddot{P}^3 + 18\,\dot{H}$.

B. *Minerals with the Composition of Organic Bodies.*[1]

I. *Oils.*

485 Mineral oil (Naphtha) ..... C, H. Mixture of Paraffine with fluid Carburetted Hydrogen.

II. *Resins.*

490 Amber..... C, H, O. Bitumen, two Resins, an Ether oil, Succinic acid.

487 Asphaltum ..... C, H, O. Asphaltine ($C^{20}\,H^{32}\,O^3$) and Resin.

485 Petroleum ..... Asphaltine and Petroline ($C^{10}\,H^{16}$).

491 Retinite ..... C, H, O. Bitumen and Resins.
(Fossil Copal, Piauzite.)

492 R. from Walchow $C^{12}\,H^{18}\,O$. Schrötter.

" Giron..... $C^{34}\,H^{53}\,O^2$. Boussing.

493 " Highgate Hill ... $C^{40}\,H^{64}\,O$. Johnston.

493 " Settling Stones $C^2\,H^3$. J.

[1] Strictly, Mellite and Oxalite also belong to this division.

494	Berengellite	$C^{40}\ H^{62}\ O^{8}$.
495	Guayaquillite	$C^{20}\ H^{26}\ O^{3}$.
497	Middletonite	$C^{20}\ H^{22}\ O$.
486	Elaterite	Chief constituent perhaps CH.
498	Ozokerite (Mineral wax)	CH.
499	Hatchetine	
504	Idrialine	$C^{42}\ H^{38}\ O$: Bödecker.
504	Idryl	$C^{3}\ H^{2}$.
503	Scheererite, from Uznach	CH^{4}. (?)
502	Könlite, from Uznach and Redwitz	$C^{3}\ H^{2}$. Tromsd. Kraus.
500	Fichtelite, from Redwitz	$C^{4}\ H^{6}$.
	Xyloretine	$C^{23}\ H^{38}\ O^{2}$. Schrött.
503	Tekoretine	$C^{5}\ H^{9}$. Forch.
503	Phylloretine	$C^{4}\ H^{5}$. Forch.
501	Hartite	$C^{6}\ H^{10}$. Schrötter. Ob = Tekoretine?
496	Hartine	$C^{20}\ H^{34}\ O^{2}$.
495	Bogbutter	C, H, O.

III. *Coals.*

483	Brown coal	C, H, O, N.
482	Stone coal	
481	Anthracite	

A. *Zygadite.* A reddish or yellowish-white mineral, much resembling albite, and occurring in macles formed by the same law, in a mine near Andreasberg. H. under 6; G. = 2·511. Subtranslucent, and lustre vitreous, inclining to pearly on the distinct cleavage planes.

B. *Alumocalcite.* Massive and friable; white, slightly yellowish, bluish, or reddish. G. = 2·148 — 2·174. Occurs at Eubenstock in Saxony.

C. *Perthite*, Thomson. Probably a variety of felspar; from Perth in Upper Canada.

D. *Thuringite*, Breithaupt. Massive, with cleavage in one direction. H. = 2 — 2·5; G. = 3·151 — 3·157. Pearly lustre; olive-green; streak siskin-green. Gelatinizes in hydrochloric acid. From Schmeidefeld near Saalfeld in Thuringia; and seems closely connected with lievrite, No. 175.

E. *Chamoisite*, probably a mixture of magnetic iron-ore with hydrous silicates of alumina; from Chamoison in the Valais.

Malthazite. A white tallow-like substance, from Lobau in the Lausitz.

F. *Iberite*, Svanberg. Probably hexagonal; with cleavage along ∞P and 0P. H. = 2·5; G. = 2·89. Opaque, resinous, light-green, or gray. B.B. fuses difficultly to a dark glass. With borax shows traces of iron, and becomes dark-blue with cobalt solution. Norlin found 40·90 silica, 30·74 alumina, 15·47 iron protoxide, 1·33 manganese protoxide, 0·40 lime, 0·80 magnesia, 4·57 potash, 0·04 soda, and 5·57 water (= 99·82). It occurs at Montalvan near Toledo in Spain.

G. *Diphanite*, Nordenskiold, from the emerald mines of the Ural. It resembles apatite. G. = 3·04 — 3·07. B.B. becomes opaque, exfoliates, and forms an enamel. Jewreinoff found in it 34·02 silica, 43·33 alumina, 13·11 lime, 3·02 iron protoxide, 1·05 manganese protoxide, and 5·34 water (= 99·87).

H. *Yttria-Spar*, Hartmann, occurs as a white incrustation on Gadolinite and other minerals from Ytterby in Sweden.

I. *Borocalcite*. This salt occurs in fine acicular crystals, white or colourless, near Yquique in South America; and, according to Hayes, contains 18·89 lime, 46·11 boracic acid, and 35·00 water (= 100).

K. *Mosandrite*, Erdmann. Indistinct prismatic crystals; with one distinct and several indistinct cleavage planes. H. = 4; G. = 2·93 — 2·98. Translucent in thin splinters; lustre resinous; colour dark reddish-brown; streak greyish-brown. In the closed tube gives much water. B.B. intumesces and fuses to a brownish-green bead; with borax forms an amethystine glass, which in the reducing flame becomes yellowish or almost colourless. Found on Lamoe near Brevig in Norway.

L. *Cryptolite*, Wöhler. Found in transparent, pale wine-yellow, acicular crystals, imbedded in the compact apatite of Arendal, and shown by dissolving the latter in nitric acid. G. about 4·6. Unaltered at a red heat. Powder soluble in concentrated sulphuric acid. Wöhler found 73·70 cerium oxide, 1·51 iron protoxide, and 27·37 phosphoric acid (= 102·58).

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